# CAMPSITE IMPACTS IN THE HIGH UINTAS WILDERNESS AREA: A STUDY OF TWO ALTITUDINAL ZONES

by Paul Rogers

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In Cooperation with Ashley National Forest
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## ABSTRACT

Twenty-five campsites were examined in four use/altitude areas for possible differences in campsite impacts. Field measurements were administered on campsites to assess impacts on ground vegetaion, soil, and trees. In addition, the author implemented a visual impact rating score (VIRS) to obtain an overall measure of campsite conditions, which included a rating of aesthetic appearance. There were three general conclusions. Reliable indicators of impact included measures of vegetaion loss, damaged trees, and the VIRS. Change in impact from low to high use was relatively minor. Subalpine forested campsites yielded significantly greater amounts of impact then lower montane sites. Recomendations for optimum campsite locations are given and possible management implications are discussed.


## ABOUT THE AUTHOR


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Questions or comments regarding this study are encouraged and should be directed to the author at either the Buffalo district of the Bridger-Teton National Forest or to P.O. Box 2584, Ketchum, Idaho 83340.




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## Section 1 - THE STUDY AND ITS SETTING

### Part I. An Introduction to Recreational Impacts in Backcountry Wilderness

The use of backcountry wilderness for recreation is rapidly growing. However, managers of these wilderness areas are continually faced with the dilemma of encouraging visitation on the one hand, and maintaining the natural character of the wildlands on the other. As Nash (1982, p. 317) points out, "...even appropriate kinds of use can, in sufficient quantity, destroy the wildness of a place." It is ironic that widespread promotion of the virtues of wilderness in recent decades has led to conspicuous human impacts in some wilderness environments. In response to this trend managers have taken a more active role in controlling use.

An alternative to stricter management policies is to vigorously promote education in camping techniques that minimize impacts. A first step in such education is to determine the different responses to human use of various environments. If environments vary in their response to human use, recreation may be regulated differently and appropriately in order to minimize impacts while maximizing recreational use. Users, as well as managers, will benefit from a greater knowledge of environmental responses to use.

It is the primary focus of this study to examine impacts of camping in two wilderness environments differentiated by altitude: the subalpine zone and the lower montane zone of the High Uintas Wilderness Area. Forested habitats within each zone are similar regardless of where they are encountered, while between zones there are marked differences. Greater knowledge of ecosystem susceptibility in these zones may lead to more efficient user and manager practices.

Specifically, this study will pursue three questions associated with backcountry camping. The first is whether or not certain measures of impact are more valuable than others? Secondly, do campsites differ significantly in their impacts between use levels? Finally, and most importantly, what are the differences, if any, between impacts incurred at lower montane campsites versus those at subalpine campsites? It is hoped that in answering these questions, and by expanding the locational applications of such studies, a contribution to the study of recreational impacts can be made.

This study will be conducted in four major sections. The first part of section 1 is intended to familiarize the reader with the study of campsite impacts in backcountry areas more generally, and to review previous studies which have looked at differences in impacts with varying use and altitude levels. In the second part of this section a description of the locational and biogeographical setting is given. Section 2 deals with the field method employed to obtain campsite condition data in the High Uintas Wilderness. In Section 3 data collected in the field is analyzed and discussed with the three above questions in mind. The purpose of Section 4 is to work the results found here into a general management framework for monitoring and maintaining campsite conditions.

## The Nature of Backcountry Impacts

The types of impact caused by humans on the natural setting vary widely. Users of off-road recreational vehicles may destroy vegetation cover in a single pass, while a hiker may spend several days in an area and leave it seemingly unscathed. Similarly, in a wilderness preserve where motorized vehicles are generally prohibited, more subtle variations in impact may take place depending on type, duration, and location of use. On campsites, differences in these three variables relate directly to the amount of impact.

Type of backcountry uses include not only one's mode of transport but also such things as the number people in the party, type of provisions, and whether campfires will be utilized. As expected, large parties will cause more damage than smaller parties, although this relationship is not a necessity one; a small group which uses a fire as a means of cooking and congregating may produce more severe impacts than a large party which does not use fire and is generally more dispersed. Size of fire ring and use of large amounts of wood are conspicuous signs of impact. Along this same line, the type of provisions carried, such as food and equipment, can influence impact. If most of the food needs to be cooked and a portable stove is not available, than large amounts of wood may be needed. If all wood is gathered immediately adjacent to the campsite, signs of overuse from peripheral trampling paths and damaged trees may become evident (Cole 1982).

To a certain degree the type and amount of provisions procured depends on the mode of transport. Stock animals, most commonly horses, allow campers to bring much more food and equipment. Most significantly, however, these animals cause a greater degree of damage to vegetation and soils through trampling than do hikers (Weaver, et al., 1978). This is due primarily to the weight of horses (including packs) and the relative sharpness of their hooves. Horse damage may be especially severe when their movement is restricted overnight on wet ground (Trottier and Scotter 1973). Horses being tied to trees results in root exposure from concentrated trampling and bark removal caused by rope friction on trunks. These types of problems can be reduced if precautions are taken, such as hobbling horses or simply not using stock animals in favor of hiking. In recent years a trend seems to be developing in which fewer backcountry visitors are traveling by horse even though the total number of users is increasing (Lucas 1985).

In addition, the duration of stay at a particular campsite also effects impact. Campers remaining in the same spot for a number of days will likely have a greater effect than those staying overnight. Those that stay for several days may make elaborate modifications to campsites (e.g. construction of seats, tables, large fire pits, shelters, etc.) in order to make them more "comfortable". Conversely, those staying for shorter periods of time seem less likely to make alterations.

A final significant influence on backcountry impacts is campsite location. Though often determined by the users, managers have attempted to influence site location by establishing wilderness rules. For example, many areas do not allow camping near lakeshores or along trails. It is felt that campers away from lakeshores will have less effect on water quality and are also less visible to other campers around a lake. Sites adjacent to trails often attract excessive use because of their easy access. Canon, et

al., (1979) attribute this high use to the perceived security of sites located near trails. Whether for security or convenience, both near-trail and near-lake campsites are used heavily despite managers attempts to discourage such use.[1]

In addition to management recommendations, other locational variables may influence the amount of impact a site receives. For example, lakes near trail heads may receive more impact than those in more remote areas simply because of their ease of access. A similar effect is observed on sites which are near scenic attractions, such as high peaks or geologic oddities.

More generally, locational variables such as slope, aspect, soil makeup, moisture, and temperature influence vegetation cover, and hence habitat composition. Different habitat types are found in specific altitudinal ranges. Since this topic is a focal point of the study, a more detailed review of susceptibility of different habitats to human impacts is included in the following section.

## A Review of Previous Studies

In the past two decades the body of literature which evaluates recreational impacts on wilderness has grown tremendously. With this in mind, I would first like to take a general look at approaches to studying this phenomenon, and then look at two topics, amounts of use and altitude, which relate more specifically to this study.

### - Approaches

The study of small scale vegetation change employs similar methods as that of large scale vegetation change. There are, however, a few important methodological differences. Studies of large scale disturbance may employ either a series of specific ecological measurements or historical sources to determine broad patterns of change. Change is often measured by comparing species composition or general landscape cover with sites which are perceived to be "natural", or relatively unaltered by human activities. Because of their size human induced changes studied on a small scale must be concerned with more site specific detail. Ecological sampling is done in much the same way as with large scale studies except that individual plants can often play a much more important role. Historical records provide too broad a picture to be useful on a small scale.

There are four basic approaches to monitoring human induced change on campsites (Wall and Wright 1977; Vale 1982; Cole 1983a; Price 1985).[2] The first is the experimental approach. The aim of experimental studies is to apply a known amount of "use", in the form of actual subjects or simulated

---

1. All sites tested in the present study, for example, were located within 150 feet of either a lakeshore or a trail, sometimes both, even though this practice is officially discouraged in the High Uintas Wilderness.

2. Although no one of these authors mentioned more than three methods, a compilation of them all did reveal four distinct approaches.

trampling devices, and record the resulting change in ground cover. The assumption is made that the "trampler" represents the average weight and motion of actual trampling. Wagar (1964) was one of the first to use this technique in attempting to define carrying capacity for wildland recreational areas. A large number of studies have used experimental methods to look at more specific questions, such as the susceptibility of alpine and subalpine ecosystems (Willard and Marr 1970; Cieslinski and Wagar 1970; Bell and Bliss 1973; Schreiner 1974; Campbell and Scotter 1975; Kuchar 1972; Holmes 1979). These studies generally conclude that the more resilient species, forbs and grasses, adapt better to trampling than woody stemmed plants. A study by Weaver, et al., (1979) looked at the effect of different types of use (hiking, horse, motorcycle) on vegetation and soils of differing slopes and moisture content. They found that hikers had the least effect on grasses found in flat, dry areas. Locations which were wet or steep were most susceptible to damage. Experimental studies of this nature are useful in that they often provide specific information on species reactions to known use levels. A problem, however, is that trampling patterns on campsites may differ substantially from the simple linear passes employed by experimental studies. Different trampling patterns can have varying affects on vegetation (Holmes 1979).

Secondly, objective measurements may be used. Objective measurements differ from experimental studies because data is collected on actual campsites already impacted by use. Data obtained is then compared to identical measures on adjacent untrampled control sites or other campsites. Frissell and Duncan (1965) set a precedent by applying a series of soil and vegetation parameters to campsites in Minnesota's Boundary Waters Canoe Area. The indicators they used were correlated with use levels. They found that use was highly concentrated on relatively few sites, and that those sites experienced extensive top soil loss and tree root damage. Dotzenko, et al., (1967), looking exclusively at soils, found that increasing use of campgrounds in Rocky Mountain National Park led to decreases in soil moisture and increases in runoff and erosion.

Studies which use objective measurements have since incorporated a variety of parameters in an attempt to find those that will best portray campsite conditions. For example, Fichtler (1980) used the following ten impact indicators to determine the effects of use on two Montana wilderness areas: number of species, vegetation cover, soil exposure and compaction, duff cover, tree growth, number of seedlings, tree injury, root exposure, and bark removal. In a more detailed study, Cole (1982) applied twenty-six parameters, including areal measurements of the total campsite and the amount of bare ground within the site. Though objective measurements provide a detailed analysis of campsites, a major disadvantage is that the length of time required to inventory individual sites may make this system cost prohibitive for most managers. Furthermore, the use of objective measurements may not account for such quantitative intangibles as excessive seat construction, wood stock piling, horse manure, or solid wastes left by campers; all of which are measures of environmental impact.

A third means by which campsites may be monitored is a subjective rating system. This method is considered more subjective because actual measurements are not taken. Instead campsites are visually assessed and assigned a rating "score". Scores are based on a continuum ranging from no impact to severe

impact.

Willard and Marr (1970), in studying human impacts on alpine tundra in Colorado, rated sites from 0 to 5 based on estimated percentages of total vegetation loss. Both Trottier and Scotter (1973) and Lesko and Robson (1975) implemented Willard and Marr's "Degree" ratings as a supplemental means of assessing alpine trails and backcountry campgrounds in Banff National Park, Canada. In addition, Lesko and Robson looked at the physical attributes of campgrounds and rated them according to their capabilities in supporting future use. Kay (1973) developed her own "scorecard" to determine the possible carrying capacity of campsites on Isle Royale National Park. In her system, sites were ranked on the basis of seven "environmental components". These components were then weighted and total campsite scores were assigned. Hendee, et al., (1976) designed a more detailed edge-punch inventory card called "Code-A-Site" which may be used in a variety of outdoor recreational settings. Although their system provides excellent detailed information, including a section to diagram site conditions and locations, it does not provide managers with an overall site evaluation score. Because of this, comparison between sites on a comprehensive level is not possible unless it is done on a parameter by parameter basis. A final rating method developed by Frissell (1978) is similar to that of Willard and Marr's, except that it takes into account soil conditions to a larger extent than they did. Though the oversimplification of its "Condition Classes" may result in considerable grouping of data,[3] the advantage of this system is the relative ease by which a fairly comprehensive assessment may be achieved. On the other hand, any visual assessment, by nature, will sacrifice detail.

Lastly, the use of photography to monitor human impacts has also been successful (Merriam, et al., 1973; Cole 1983a; Price 1985). Merriam, et al., constructed a five year photographic record of new campsites in the Boundary Waters Canoe Area, Minnesota. On each site a photo point was marked and a picture of the campsite was taken from that point each year. Cole photographed campsites from the center outward in a 360 degree circle. These photos were then be pieced together to form a panoramic photo mosaic. Price (1985) used both ground and air photos to document conditions surrounding alpine trails in the southern Canadian Rockies. The use of air photos to monitor campsites not found in meadows seems of little use given the restriction of canopy cover. Aerial photography in general may be too expensive to use as a complete inventory system at this time. Photos taken from the ground, however, can be useful in determining general pattern changes, especially if an extensive historical record is available. It should be noted though, that certain precautions must be taken to replicate the exact lighting conditions of the original photos. This may be difficult given the dynamic quality of the forest canopy. Sunlight reaching the campsite itself will change from year to year depending on the growth and/or destruction of tree limbs and foliage.

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3. Some criticisms of Frissell's "Condition Class" system are dealt with in the following section under the Impact Indicators subheading, when discussing the development of the Visual Impact Rating Score.

- Effects on Amounts of Use

Although wilderness use has been monitored in a variety of manners (i.e. estimates, self-registration boxes, automated counters, mandatory registration permits), no system can provide a completely accurate count. The best that land managers can do is to estimate the number of visitations to a given area. Determining the number of visitors to specific campsites is nearly impossible given the number and dispersal of campsites in most wilderness areas.

For the purposes of determining effects of amounts of use, use categories may be established to see if impacts are dissimilar at various use levels. In the past category groupings have been defined both dichotomously and ordinally. For example, Coombs (1976) and Fichtler (1980) applied an array of impact variables to sites of low and high use in Idaho and Montana respectively. In each case use was determined by on site self-registration boxes. Coombs found significant differences in many of her variables between use levels, while Fichtler noted only a significant difference in soil exposure levels. Cole (1982), on the other hand, divided his use levels ordinally into light, moderate, and heavy use categories. In an effort to statistically compare use levels, however, mean value ranges for indicators often overlapped use categories. For example, percent bare ground had a light-use mean of 30 $\pm$ 28, moderate-use was 26 $\pm$ 19, and heavy-use was 40 $\pm$ 16. These use divisions may have been at fault for the many statistically insignificant relationships.

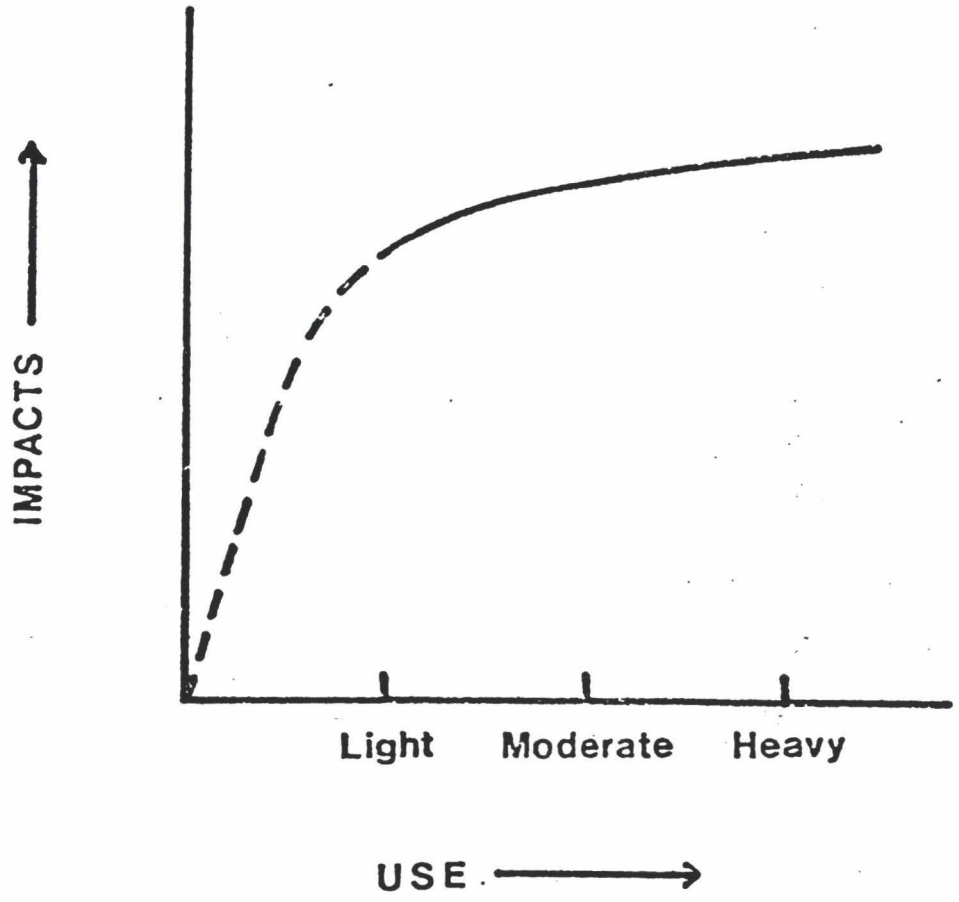
Nonetheless, in all of the above mentioned studies increased impact results from increased use. Exactly how much change takes place along a continuum from no use to heavy use is a question which Cole (1982) evaluated. He found that impacts increase substantially from no use to an arbitrarily defined light use, and then increase at a declining rate with additional use (see figure 1.1). Vegetation species which are most susceptible to trampling will probably die off with light use, while those that are more durable will eventually colonize as much as use allows (Coombs 1976). The attempts of these adaptable species to reproduce the original groundcover is kept in check by continued use. In other words, compared to the initial impacts that occur with light use the differences between impacts of successive use levels are relatively minor.

- Impact Variation Between Altitudinal Zones

The question of habitat fragility is central to the discussion of variation in impacts between elevational zones. Altitudinal zones are marked by various species which react differently to human impacts.

Areas which consist largely of grasses and forbs, as in meadows for example, have been found to be less fragile, and therefore more resistant to human trampling than forested areas (Roemer 1975; Cole 1979,1982,1985; Fichtler 1980; Weaver, et al., 1979; Holmes 1979). On the other hand, while meadows may be more resistant to trampling, short growing seasons in high elevation zones leave little time for recovery of damaged vegetation (Thornburg 1962; Cieslinski and Wagar 1970; Kucher 1972; Bell and Bliss

Figure 1.1 Relationship of Impact to Amounts of Use




1973). Furthermore, late snow melt and frequent precipitation provide moist conditions which have been shown to increase trampling damages (Willard and Marr 1970; Kucher 1972; del Moral 1979). These results suggest that impacts may vary depending on specific site conditions within ecological zones or habitat types. This does not, however, address differences between zones.

Although a number of studies have looked at impacts incurred in specific backcountry ecosystems, few have attempted to compare directly variations between altitudinal zones. Among the limited work that has addressed these variations are those studies of Cole (1982 and 1983b) and Cieslinski (1970).

Data presented by Cole has suggested that subalpine sites are more durable than boreal campsites at lower elevations. However, these conclusions appear to be drawn from minimal evidence. His study of the Eagle Cap Wilderness (1982) directly compares only four sites for altitudinal differences; two lower valley sites and two at subalpine sites. Those sites located in the subalpine meadows were classified as receiving light and moderate use, while the lower forested sites received moderate and heavy use. In the second study (1983b), Cole uses data from other research sites (Coombs 1976; Fichtler 1980; Cole 1982) and compares them to low elevation sites in the Bob Marshall Wilderness in Montana. This comparison is made with little regard for differences in use levels between the various research sites. Yet he concludes, once again, that lower elevation sites are no more resistant to impacts than upper elevation sites. In both cases very little evidence is presented in which forested (or meadow) sites are directly compared between elevation levels.

Cieslinski and Wagar (1970) present alternative conclusions in their study conducted in northern Utah. Using a simulated trampling device in forested campgrounds they concluded that "...surviving vegetation decreased as elevation increased." (p.7). They attributed these results to the shortness of the growing season and the relative fragility of plant species at higher elevations during early developmental stages. They surmised that heavy trampling coincided with this period of fragility and therefore resulted in high vegetation mortality at upper elevations. As with the studies done by Cole, differentiation between impacts at different altitudinal levels was not the main thrust of their study, and consequently minimal data are provided to support these conclusions.

## Part II. Location and Biogeographical Setting

### Location

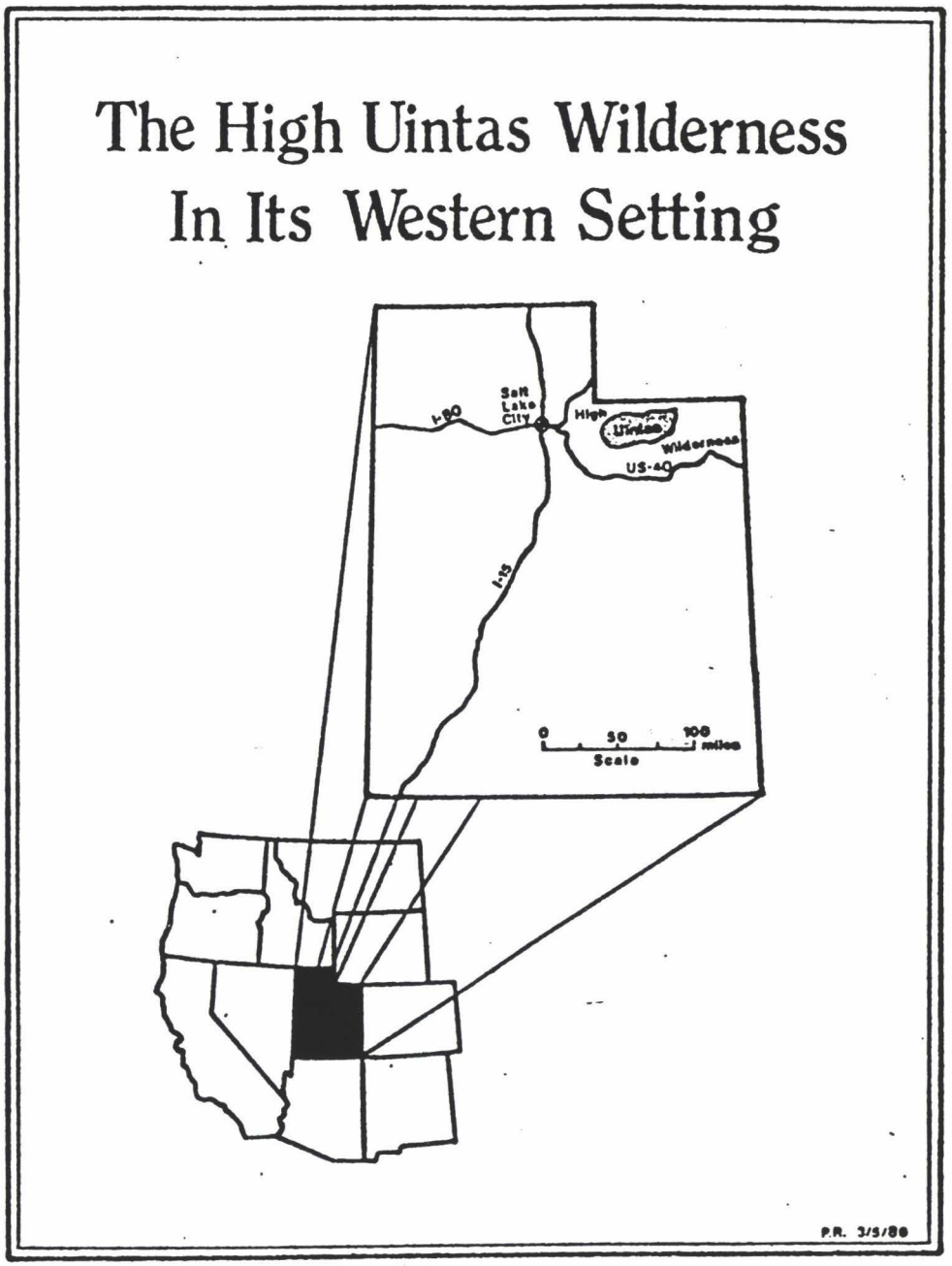
Both the state of Utah and the High Uintas Wilderness Area (HUWA) maintain a central location within the American West (see figure 1.2). The major urban center of Utah, Salt Lake City, is located approximately 150 miles to the west of the HUWA. Access to the HUWA is gained from Interstate-80 on the north or U.S.40 to the south and west.

The HUWA is located within the loftier western half of the Uinta mountains. Jurisdiction over the HUWA's 460,000 acres of alpine terrain is shared by the Ashley and Wasatch National Forests.

The study area itself is located entirely on the south slope of the Uintas within the Ashley portion of the wilderness area. All test sites are found in three major drainage basins: Lake Fork, Yellowstone, and Uinta (see figure 1.3).

All three drainages within the study area flow to the south through the Uinta basin and eventually into the Green and Colorado river system. These rivers have downcut within the glacial valley bottoms. As a result of this, trails and campsites located parallel to streams are often perched on former glacial valley bottoms up to 100 feet higher than the stream beds themselves.

Figure 1.2


The High Uintas Wilderness
In Its Western Setting
I-80
Salt Lake City
High Uintas Wilderness
US-40
I-15
0
50
100
miles
Scale
P.R. 3/5/80

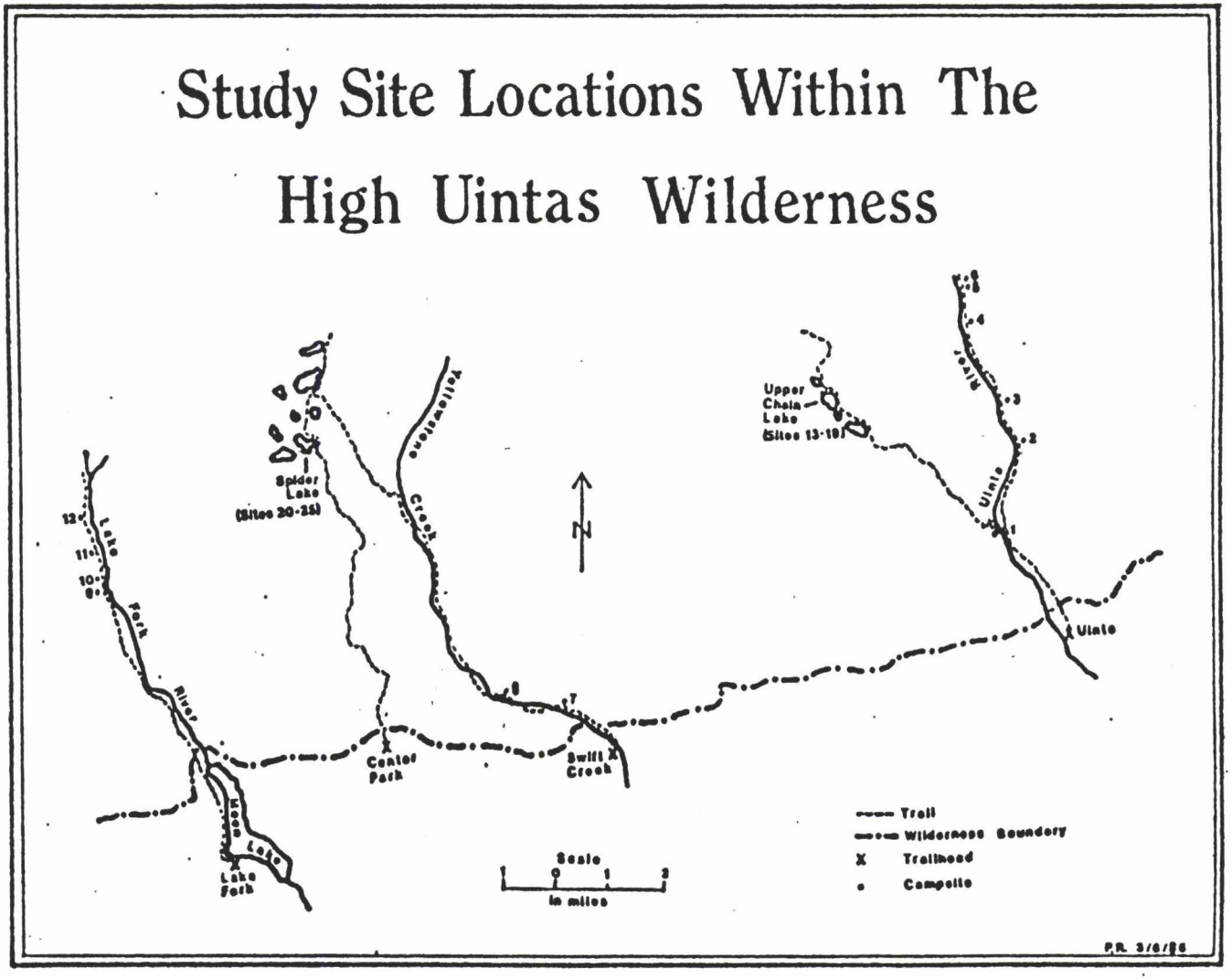

Study Site Locations Within The
High Uintas Wilderness
Spider Lake (Sites 20-25)
Yellowstone Creek
Upper Chain Lake (Sites 13-19)
Uinta River
Uinta
Lake Fork River
Center Park
Swift Creek
Moon Lake
Lake Fork
N
Scale
0 1 2
in miles
Trail
Wilderness Boundary
Trailhead
Campsite
P.R. 3/6/86

Figure 1.3

Biogeography

There are distinct changes in forest vegetation as altitude increases in mountainous environments. In general, throughout the Intermountain West there is a gradual transition as altitudes increase from habitats dominated by ponderosa pine (Pinus ponderosa) overstory, to those which are predominately lodgepole pine (Pinus contorta), and finally to a spruce/fir (Picea ssp./Abies ssp.) controlled canopy. Within the thirty six habitat types identified in northern Utah by Mauk and Henderson (1984), four were observed on the south slope study sites:

Picea englemannii / Vaccinium scoparium h.t.
Abies lasiocarpa / Vaccinium scoparium h.t.
Pinus contorta / Juniperus communis c.t.
Pinus contorta / Berberis repens c.t.

The first two were found primarily above 10,000 feet, while the latter two were found below 9,000 feet. Between these two elevations a transition zone occurs.

Common overstory and understory species have been plotted along a hypothetical altitudinal profile of the study area (figure 1.4). From this illustration some very general relationships may be observed. As altitudes increase the overstory becomes more dispersed and understory more dense. In conjunction with this, the overstory decreases in height to the point where, within the forest-alpine ecotone, common coniferous species are reduced to shrub or mat form.[4] A relative decrease in the stature of understory species occurs with altitude increases, as well. A more compact morphology is thought to be an aid in protecting vegetation from harsh alpine climates.

Now that we have provided a background for this study, let us move on to a closer look at the methodology used to obtain data on campsite impacts in the High Uintas.

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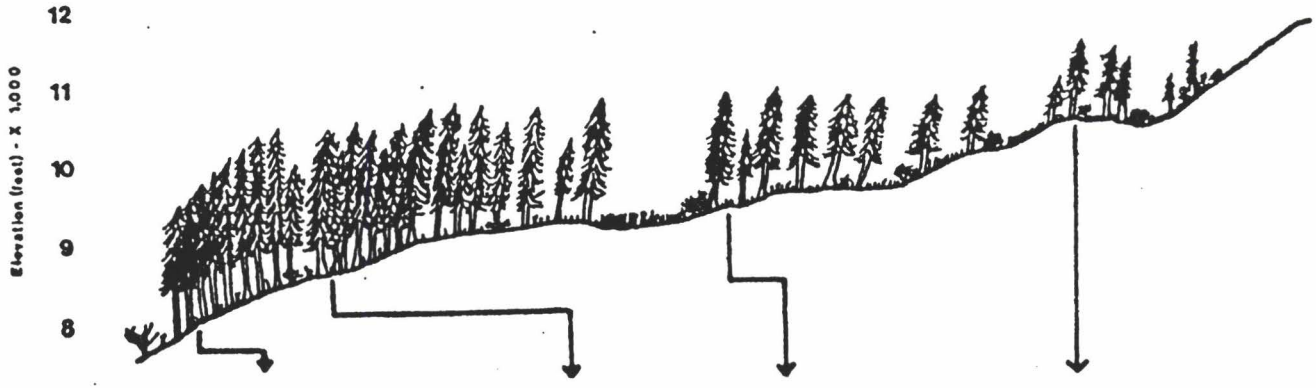
4. See Hansen Bristow (1980) for further discussion of changes in the morphology of coniferous species as they approach treeline.

Figure 1.4

# Hypothetical Profile of the Uinta Mountains (South Slope)




| | | | | |
|---|---|---|---|---|
| Overstory | Pinus contorta | Pinus contorta | Picea englemannii | Picea englemannii |
| | Pseudotsuga menziesii | Populus tremuloides | Pinus contorta | Abies lasiocarpa |
| | Populus tremuloides | Picea englemannii | Juniperus communis | Ribes montegirum |
| | Juniperus communis | Juniperus communis | Berberis repens | Vaccinium scoparium |
| Understory | Poa secunda | Berberis repens | Arnica cordifolia | Achillea millefolium |
| | Geranium richardsonii | Poa secunda | Vaccinium occidentale | Poa nervosa |
| | Antennaria rosea | | | Castilleja applegatei |

## Section 2 - METHODOLOGY

### General Procedure

In general the methodology consisted of site selection, site inventory, and data analysis. The former two of these will be dealt with in this section while the latter will be covered in the following section. The analysis of data will involve considerable discussion and therefore, it is felt, merits a separate treatment. Before describing the details of the site selection and inventory process, I will present a brief overview of the field procedure, followed by a description of each of the campsite measurements used.

Sampling areas were selected prior to actual field work on the basis of altitudinal zones and Forest Service use records. Two use groupings, high and low use, and two altitudinal zones, high and low, were employed in the study. Selection of individual sites within each of the four sampling areas was done in the field according to predefined guidelines discussed below. Once sites were selected in a given sampling area, data was collected on the sites themselves, as well as on adjacent unused sites which acted as controls. Data collection consisted of eight actual field measurements and an overall visual rating score. Campsite-control pairs were later evaluated for differences in vegetation cover and amount of soil exposure. Information regarding common overstory, shrub, and ground cover species were also recorded at each site. All information gathered was later analyzed to determine the differences, if any, between human impacts incurred at high and low altitude and high and low use sites.

### Description of Impact Indicators

Nine impact indicators were used to evaluate campsite conditions.

Total Camp Area
Percent Bare Area
Absolute Vegetation Loss
Relative Vegetation Loss
Absolute Change In Mineral Soil Exposure
Relative Change In Mineral Soil Exposure
Absolute Damaged Trees
Percent Damage Trees
Visual Impact Rating Score

Indicators were chosen largely because of their success in previous studies of this nature (see Coombs 1976; Fichtler 1980; Cole 1982; Cole and Fichtler 1983), and on their applicability to this particular study area. Each is described below.

Total camp area is the continuous area of ground with less than 10 percent estimated vegetation cover within a 3 X 5 foot quadrat. Cole (1982) had used a minimum figure of 15 percent, but in many cases, especially in

those areas where a dense overstory was present, even control areas did not have a 15 percent ground cover.[1] In a few cases it was felt that campsite perimeter had to be determined by overriding factors other than vegetative cover, such as the intersection with a trail. Much of the trampling done on trails cannot be attributed to individual campsite users and therefore could not be considered as part of the camp area. Other natural boundaries, such as rivers, lake shores, boulder fields, and cliffs, were likewise used to delineate camp areas.

Percent of bare area is the continuous percentage of the total camp area which has less than one percent vegetation cover and no more than 50 percent litter accumulation. In most cases this area consisted largely of a fire pit and its encircling rocks, some bare mineral soil which may of had partial duff or litter cover, and exposed parent material. On especially rocky sites parent material may account for relatively high percentages of bare area.

Absolute vegetation loss is the difference between the estimated vegetation cover on the control site and the estimated cover on the campsite. Relative vegetation loss is the absolute loss expressed as a percentage of the estimated vegetation cover on the control site. For example, if there is a 90 percent ground cover on the control site and a 10 percent cover on the campsite, than the difference between these, 80 percent, would be the absolute loss. Therefore, the relative loss would be about 89 percent (80=88.88 of 90). The advantage of this type of measurement is that in the event that ground covers are highly variable, which they often are, one may derive a base percentage value which may be directly correlated with areas of differing ground cover. With this type of measurement a control-campsite pair which shows a 10 percent cover and 9 percent absolute loss may be viewed as equal to a site which shows a 90 percent loss from a 100 percent control cover.

Absolute and relative increase in mineral soil exposure are derived in a nearly identical fashion as vegetation loss. Mineral soil was characterized as being any area in which bare soil, composed of 50 percent or less duff cover, and/or parent material was exposed. In some cases, due to extensive outcroppings of parent material, even control sites revealed relatively large percentages of mineral soil exposure. Rock outcrops, though often naturally occurring, may provide indications of human use, which often further exposes rocks either by trampling or dislodging for campsite modification.

Absolute damaged trees is the total number of trees and shrubs greater than breast height within a 50 foot radius of the campsite center point which have been either felled, scarred, or have damaged roots visible. Relative

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1. Differences in ground cover may be attributed to local climatic influences. Annual precipitation may be as much as ten inches more in the Wallowa mountains of northeastern Oregon where Cole (1982) tested the above mentioned scheme. The Wallowa mountains annually exceed 40 inches of precipitation per year, while study sites in the Uintas receive only 30-40 inches (see Dart 1981, p. 131132; U.S.D.A. For. Serv. 1979, p. 17; Greer, et al., p. 66).

damaged trees uses this figure as a percentage of the total trees and shrubs greater than breast height within a 50 foot radius. In most cases this large radius exceeded the camp area perimeter by 10-30 feet. Fichtler (1980) used a 50 square meter plot which also exceeded his test sites in order to monitor seedling density. In the present study, peripheral tree monitoring was done purposely in order to gain a further understanding of impacts which occur outside, as well as within, campsite "boundaries". In heavily used areas felling of trees and branches for firewood and stripping of bark may be at least as common away from the trampled sites as on the campsite itself.

The final impact indicator is the Visual Impact Rating Score (VIRS), which was designed by the author to provide an overall subjective rating of each campsite. The VIRS is really an elaboration on Frissell's (1978, p.483) "Condition Class" system, which is printed below:

| Condition Class | Visible Indicators |
|---|---|
| 1 | Ground vegetation flattened but not permanently injured. Minimal physical change except for possibly a simple rock fireplace. |
| 2 | Ground vegetation worn away around fireplace or center of activity. |
| 3 | Ground vegetation lost on most of the site, but humus and litter still present in all but a few areas. |
| 4 | Bare mineral soil widespread. Tree roots exposed on the surface. |
| 5 | Soil erosion obvious. Trees reduced in vigor or dead. |

The intent of Frissell's system is to assign a class to each campsite along with specific management instructions to maintain that campsite with the least possible impact.

There are, however, a few problems with the above method. In his study of the Eagle Cap Wilderness, Cole (1982, p. 28) points out a few of the shortcomings of Frissell's simplified rating system. First of all, the five "condition classes" provided were so general that it became difficult to distinguish ratings for individual sites. For example Condition Class 4, "Bare mineral soil widespread. Tree roots exposed on the surface.", may apply to most every site. A second problem with these general groupings is that they do not present any measurement of individual parameters, such as soil loss or ground cover. Cole further suggests a system wherein these individual parameters may be rated separately. Essentially this is exactly what the VIRS is attempting to accomplish.

The VIRS is a subjective checklist which provides a quick summation of campsite conditions by rating the amount of impact in three basic categories

(four parameters): soil, vegetation understory, and vegetation overstory, and a miscellaneous "Other" category (see figure 2.1). The "Other" category contains items such as added structures, on-site garbage, human or stock animal feces, relocation of rocks, and size of fire ring. Amount of points for each parameter increases with increasing severity of impact (from 0-5). A brief explanation of ratings for each parameter provides a guideline for campsite evaluation (see appendix I ). A mean rating between values was noted (e.g. between 3 and 4 = 3.5) when a site's conditions were difficult to categorize. By summing the ratings of the four parameters an overall score may be used to compare with other sites and also be kept as a record for future evaluation of change, not only with sites generally but also with the particular sites used in this study. The goal of the VIRS is to provide a uniform means by which managers might subjectively monitor changes in campsite impacts with minimal loss of time and money.

## Site Selection

Although specific sites could not be determined until in the field, an attempt was made to define site areas as much as possible before entering the study area. Site areas were chosen on the basis of altitude and amount of use. Furthermore, individual site selection procedures were determined before hand to avoid problems which may arise when designating sites of heavy impact as "heavy use". The following is a discussion of the site selection process in three phases: altitude, use levels, and selection of individual sites.

The two general guidelines used in selecting possible site areas by altitude were, (1) to keep all possible site areas out of the altitudinal transition zone between lower montane and subalpine forests; and (2) to make sure the area was low enough to have some forest cover.

On the south slope of the Uinta mountains the transition between the lower montane zone and the subalpine zone is 9,500 and 10,400 feet (van Balen 1973; Mauk and Henderson 1984; Greer, et al., 1981). Treeline is at approximately 11,000 feet. Therefore all high elevation sites were to be located between 10,400 and 11,000 feet, while all lower elevation sites were below 9,000 feet. Because of individual site selection methods discussed below and the limits of the wilderness area (for which use data were available), an a priori lower limit of about 8,000 feet was established for the purposes of this study.

Monitoring wilderness use is an inherently difficult problem. Because of the size of most wilderness areas it is virtually impossible to contact every visitor. Moreover, sporadic use makes it difficult to implement accurate projections of use from sampling. Various methods to monitor use have either been too costly or ineffective (Lucas 1971). Self registration boxes at trailheads have been widely used in the past, but low compliance rates from users have proven to be a problem (Lucas 1975; Peterson 1985). It is for precisely this reason that the High Uintas Wilderness Area (HUWA) no longer uses the self registration system. Instead, estimations based primarily on the observations of wilderness rangers are used. Basically, the ranger keeps

Figure 2.1

## VISUAL IMPACT RATING CHECKLIST

Site Location:

Trail Head_____

#____

| Impact | Soil | Vegetation: ground | Vegetation: trees | Other |
|---|---|---|---|---|
| (none) 0 | | | | |
| 1 | | | | |
| 2 | | | | |
| 3 | | | X | |
| 4 | X | X | | |
| (severe) 5 | | | | X |

Total Score 16

Recorder's Name _____

a weekly tabulation of visitor encounters throughout the primary visitor season[2] for a particular designated area, usually a major basin. The next step is to sum the weekly tabulations and multiply by an estimated factor of visitors not encountered to arrive at a yearly total. Estimates of visitors not encountered are gained from a variety of sources, including interviewing campers, and making head and car counts at trail heads when personnel are available. For example, if the ranger only observed about one of every 3 people that year, than the yearly total would be 3 times the amount of the observed visitors. The yearly total can then be divided by the number of weeks in the season to derive a weekly average of visitors to a given area. Usually the yearly total is multiplied by two to convert to amount of visitor days. These estimates are then submitted as the basis for the official use records. In short, use data is based on a series of educated guesses.

Given the amount of "looseness" in visitor use records it became apparent that the use classifications made for this study could only be dichotomous; that is, high and low use. This was not viewed unfavorably, however. Further division of use levels may have led to some of the same problems encountered by Cole (1982). In utilizing light, moderate, and heavy use classifications he found a great deal of overlap between use levels during his analysis stage. Fichtler (1980, 40), on the other hand, found that because of "natural breaks in the data", high and low use categories were much more workable.

Final selections of high and low use areas to be studied were based on Forest Service use records for the previous three years and personal observations made by the recreation forester of the Roosevelt ranger district (Sims, personal communication).[3] The latter was especially helpful in pointing out significant use characteristics such as hiker versus horse use. All four areas had an observed rate of approximately 70 percent hikers and 30 percent horse users.[4] This would act as an important control since horses have been shown to have heavier impacts than hikers under similar conditions (Weaver, et al., 1979).

Two complementary sources were used to determine use classifications. The first were the average weekly summations of wilderness rangers. Areas considered to be high use had an estimated visitor rate of 150 people per week

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2. The primary visitor season for much of the middle and upper slopes of the High Uintas is July 1 - September 10, or about 10 weeks. Some lower valley floors may be accessed for up to 16 weeks, June 1 - September 15.

3. It should be noted that it is not known exactly how long these sites have been in use. Therefore, use could not be calculated in "number of visitor seasons", or a similar measure. Though it would be optimum to inventory sites from their inception, as Merriam, et al., (1973) did, this was not possible given the limited nature of this study. Instead, recent use records were assumed to represent total use here.

4. Uinta Canyon showed a much higher horse use rate, but most of that use was along the trails and not at lower elevation campsites. Most horse parties could travel up to 15 miles a day without difficulty (Sims, personal communication). This would put them far beyond low elevation sites.

or more, while those considered to be low use experienced less than 100 visitors per week. A second criteria used was to rank the number of total visitor days for the year by use areas and use activities. Recreational data by area and activity are provided on standard Forest Service RIM (Recreation Information Management) summaries. Examples of activity breakdowns include fishing - lakes and ponds, streams and rivers; hiking and camping; horse back riding; etc. Areas that consistently ranked as having greater relative use in the various activities were considered "high use". Likewise, those areas which consistently showed low use for activities were considered "low use". By combining both sources, a workable facsimile of use patterns could be discerned.

The final task was to go into these areas with a predefined set of guidelines for specific site selection. Foremost among these guidelines was that the sites have an "active" fire ring. I did not sample sites which showed no signs of recent use (i.e. no trampled ground and small or scattered fire ring with heavy litter and vegetation growth within the ring itself). It was felt that use of these sites was so infrequent (perhaps 1 or 2 nights per year) that little could be gained, in terms of habitat response, from the measurement of their minimal impacts. Kay (1973) used a similar method of selecting "easily located sites" which were "clearly identifiable" in her study of campsite carrying capacity in Isle Royale National Park (p. 9).

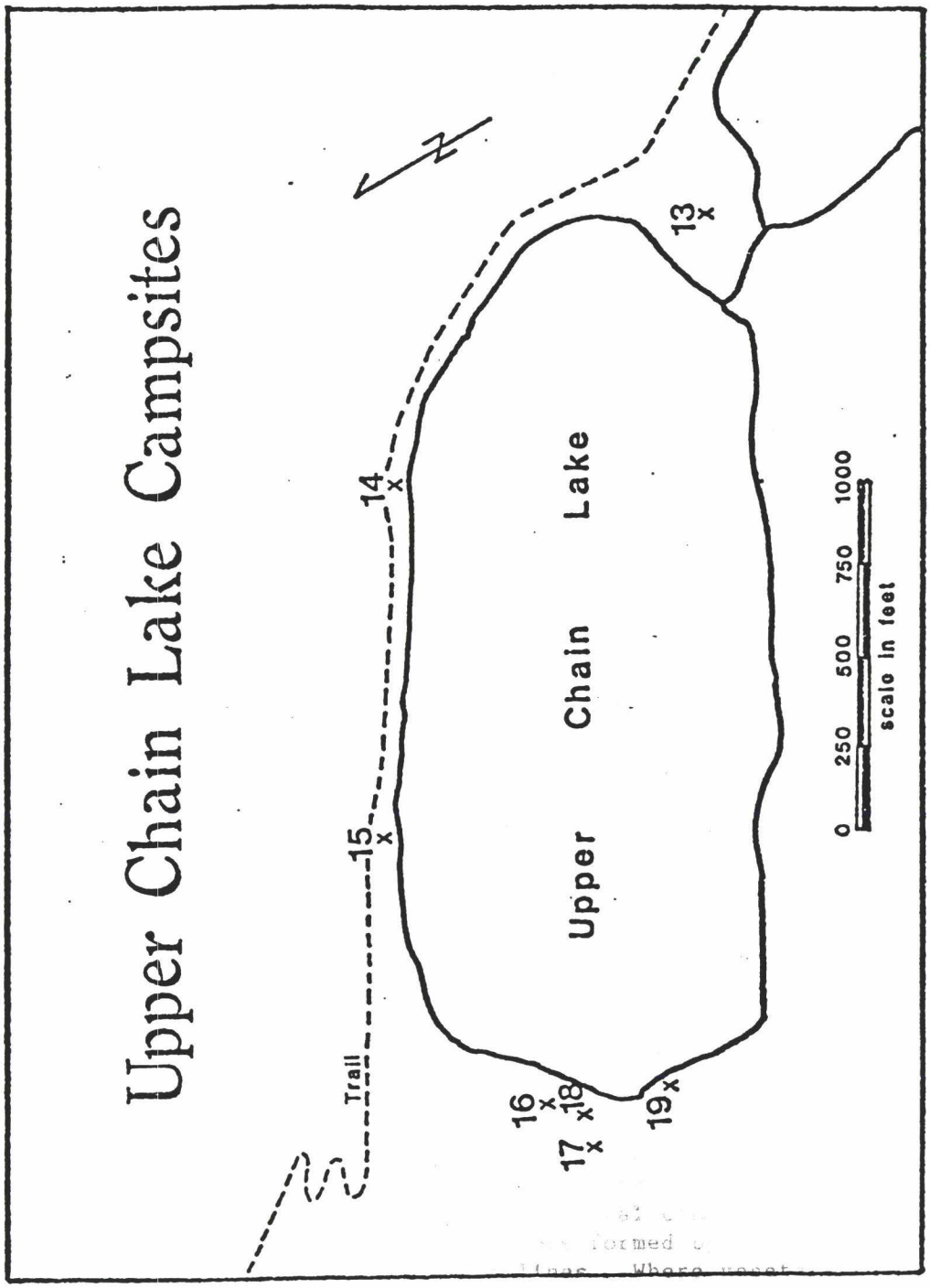
In the case of lower canyon bottoms, sites were oriented linearly along either the trail or the stream, which ran parallel to each other. Since it was known from consultation with the local Forest Service office that sites were limited in low lying canyons, every site from the upper altitudinal limit to the boundary of the wilderness area was evaluated. This selection provided six sites in Uinta Canyon (high use) and six between both Yellowstone and Lake Fork canyons (low use) (see figure 1.3).

Upper elevational sites were chosen on the basis of their orientation around a single lake within the basin which was suitable for at least five campsites and was located on a main trail above 10,400 feet. I felt that lakes located off the main trail would not represent the amount of use assumed characteristic for the area as accurately as those on the trail. Seven campsites were surveyed around Upper Chain lake, which represented a subalpine - high use location (see figure 2.2). Six sites were chosen around Spider lake to act as the subalpine - low use location (see figure 2.3). Around lakes where meadows were present only sites with overstory were studied. Table 2.1 provides a summary of all sites tested by use and elevation.

## Site Inventory

All data gathering was completed during the 1985 summer use season. Approximately one week was spent in each altitude - use area. In all cases at least two days of that week were spent in accessing the campsites. The other five days were spent surveying campsites. The study period coincided with the wettest portion, and consequently the lowest use period, of the summer use season. This was done by design so that minimal delays would be encountered

Figure 2.2


Upper Chain Lake Campsites
Upper Chain Lake
Trail
13
14
15
16
17
18
19
0 250 500 750 1000
scale in feet

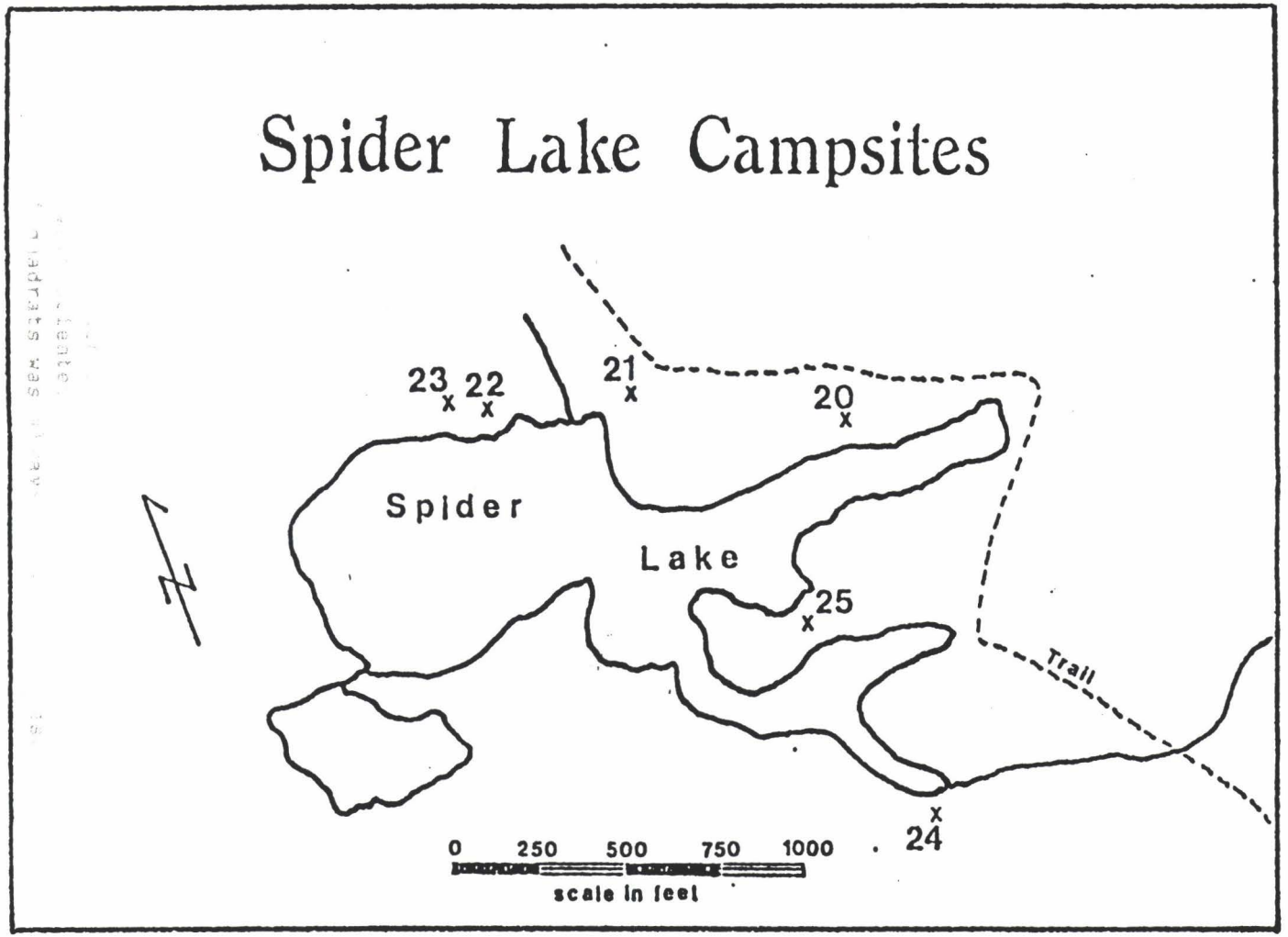

Spider Lake Campsites
23
22
21
20
Spider
Lake
25
Trail
24
0 250 500 750 1000
scale in feet

Figure 2.3

Table 2.1

| ELEVATION | USE: high | USE: low |
|---|---|---|
| low (lower montane) | 6 | 6 |
| high (subalpine) | 7 | 6 |

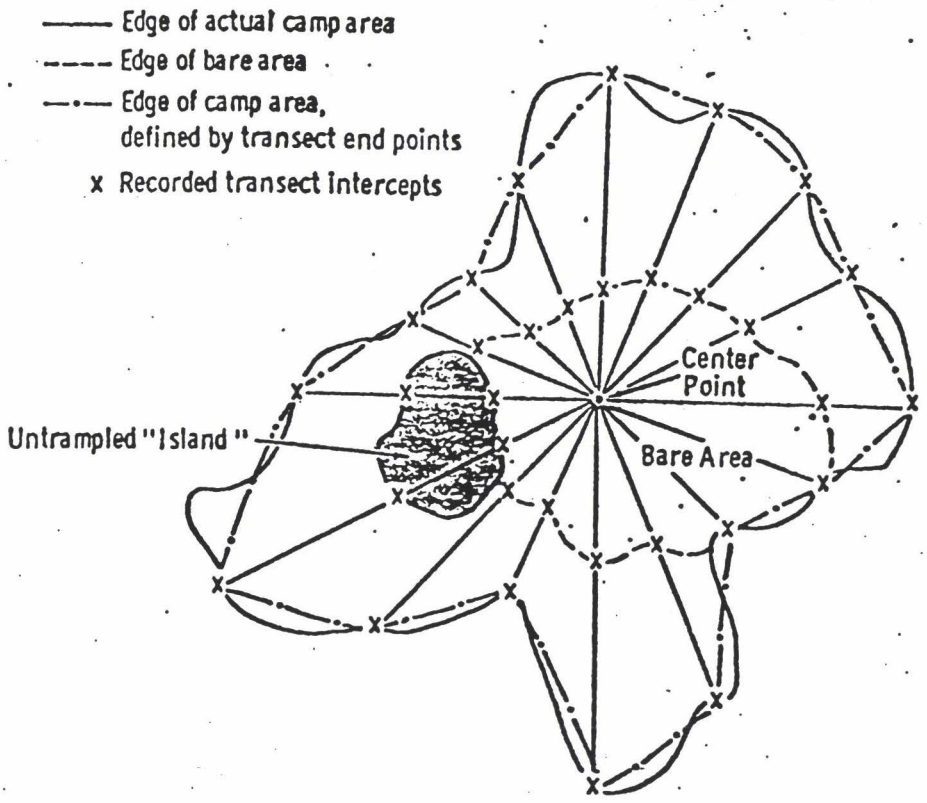
by having to wait for campers to leave designated test campsites. As it turned out this approach proved to be fruitful. I began to find conflicts with campers only within the last week of fieldwork as the daily cycle of rain began to diminish.

The site inventory procedure consisted of first assigning a VIRS to the campsite and then applying the objective measurements. It was felt that by first procuring the VIRS, biases that may have been obtained through more rigorous data gathering methods would be reduced. With that thought in mind, the following procedure was applied to all sites in an identical manner.

The first step was enter a brief description of the location, including elevation, the main access trailhead, and a study site number on the VIRS sheet (see figure 2.1). Second, I assigned a VIRS value to the campsite. Numbers were assigned in order of testing. Lower valley sites were first, starting with the high use area followed by low use, then subalpine lakes in the same manner. By making these brief notations, exact sites can be retested to monitor possible future changes in campsite conditions. The actual rating system itself, once I became familiar with parameter explanations (see appendix I ), requires only 5-10 minutes to complete.

The determination of the total camp area was, in part, to lay the groundwork for most of the subsequent data gathering. The methodology employed here is based largely on that used by Cole (1982). To begin, an aluminum stake was arbitrarily placed in the center of the campsite fire ring. This acted as the camp center point. Next, principal linear transects were established in the four cardinal directions as determined by a field compass. Transect lines were terminated and marked at the first point where vegetative ground cover exceeded 10 percent by quadrat estimates, except in cases of vegetative "islands". Twelve additional transects radiated out from the center point in similar fashion at equal intervals (- 22.5 degrees). The campsite area was delineated by connecting adjacent termination points of all 16 transects (see figure 2.4). Similarly, the bare area was enclosed by a polygon formed by connecting the first point out from the center along each transect where litter exceeded 50 percent of soil cover. Total camp area was computed by summing the area of the 16 triangular sections formed by adjacent transects and their corresponding terminal connecting lines. Where vegetative "islands" were present their area was subtracted from the total campsite.

Figure 2.4 Diagram of Camp Area and Bare Area (from Cole, 1982, p.4)


Edge of actual camp area
Edge of bare area
Edge of camp area, defined by transect end points
x Recorded transect intercepts
Center Point
Untrampled "Island"
Bare Area

Bare area was determined in the same manner. Percent bare area was then calculated on the basis of the total camp area.

The four principal transect lines were maintained for the purpose of sampling ground cover on the site. The length of these principle transects determined the number of sampling quadrats used on the site. A maximum of twelve quadrat samples, three per transect, were taken. Quadrats were 3 X 5 feet square and placed equidistantly along the transect excluding the fire ring. Since campsites are not symmetrical, some transects were shorter, and therefore fewer quadrats were employed.

In addition to sampling at campsites, an adjacent control site was also sampled at each site. Control sites were chosen on the basis of their physical similarities to campsites (i.e. slope, canopy cover - percent and species, number of outcroppings present). An average principal transect was taken from the campsite and used for each of the four transects on the control site. Control transects were again oriented towards the four cardinal directions. The same number of quadrats was always used for corresponding campsite - control pairs.

Estimates of percent vegetation and soil cover were taken in all quadrats. This was done by estimating the percent coverage in each of six square foot sub-quadrats, totaling these estimates, and dividing the total by

six to find the estimated percent coverage of that sample. In turn, the quadrat estimates were totaled and averaged to come up with average estimates for both campsites and control sites. Differences between campsite - control pairs made up absolute change figures.

The last measurements to be taken on campsites were the absolute tree damage and percent tree damage. This was done simply by attaching one end of a 50 foot string to the center stake, choosing a starting point, and walking a circumference line around the camp area while tabulating all scarred trees and total trees greater than breast height. In cases where scarring was not obviously a result of campers, trees were not considered "damaged".

Before leaving the site common overstory and shrub species were noted. Ground cover species were pressed and transported for later identification (see appendix II for complete listing of common species).

## Section 3 - ANALYSIS AND DISCUSSION OF CAMPSITE INVENTORY

Statistical evaluations of data collected in the field were focused on three questions: (1) Are some impact indicators more valuable than others?; (2) Are there significant differences between impacts incurred at high and low use levels?; and (3) Are there significant differences between impacts incurred on forested lower montane campsites and those incurred on forested subalpine sites, given similar use levels?. The following is a response to each of these questions.

### Evaluation of Impact Indicators

The strength of the impact indicators was evaluated by means of simple linear regression. All impact indicators were plotted against each other using SCATTERGRAM, a computer program developed as part of the SPSSX software package to graph scatter plots when given X and Y coordinates (SPSS Inc. 1983). In addition to the graphic printout, Pearson's r, $r^2$, and significance of r values were given for each indicator correlation. In all, 36 scatter plots were produced with their accompanying correlation values. Indicator pairs were considered significant at the .01 level or less. The relative strength of valuable indicators was determined by their $r^2$ scores. All scatter plots were examined to check for possible curvilinear relationships, but none were found. Curvilinear patterns may have developed had a larger sample been examined.

Correlations varied in strength and meaning and some were weak (Table 3.1). Correlations between absolute and relative values are predictably high, but are of little worth given their close inherent relationship. Total camp area also proved to be poorly correlated with other variables. Its weakness is rooted in the concept of attempting to define camp "boundaries". In reality, campsites do not have an actual "size", because vegetation cover does not diminish at a distinct point, but rather it gradually declines from the camp center. Furthermore, many dry areas barely possess the minimum plant cover that supposedly defines and surrounds sites. As a consequence, sites which showed very little impact, but were located in sparsely vegetated areas, produced some of the largest camp areas. Therefore, attempts to relate this measurement to impact seem rather dubious.

On the other hand, there were some particularly strong indicators of impact, including the VIRS, absolute and relative vegetation loss, and absolute and percent damaged trees. The VIRS yielded significant correlations with both measures of vegetation loss and damaged trees. A moderate correlation was also found between the VIRS and absolute change in mineral soil exposure. These results confirm the ability of the visual rating to provide an adequate measure of campsite conditions. Four out of eight objective impact indicators correlated significantly with the VIRS. Two of these, absolute vegetation loss and percent damaged trees, were highly significant correlations (i.e. .001 significance level). Only one other indicator, absolute vegetation loss, showed significant correlations with as many other indicators as did VIRS.

Table 3.I Pearson's r and ($r^2$) Values for All Impact Parameters

| | TCA | PBA | AVL | RVL | ACMS | RCMS | ADT | PDT |
|---|---|---|---|---|---|---|---|---|
| | | | ** | * | | | * | ** |
| | .143 | .148 | .566 | .511 | .424 | .286 | .540 | .603 |
| VIRS | (.020) | (.022) | (.320) | (.261) | (.180) | (.082) | (.292) | (.363) |
| | | ** | | | | | | |
| | X | -.575 | -.208 | .101 | -.319 | -.217 | .052 | -.005 |
| TCA | | (.330) | (.043) | (.010) | (.102) | (.047) | (.003) | (.001) |
| | | | * | | * | | | |
| | | X | .425 | -.042 | .699 | .321 | -.048 | .197 |
| PBA | | | (.181) | (.002) | (.481) | (.103) | (.002) | (.039) |
| | | | | | * | | | ** |
| | | | X | | .482 | .315 | .379 | .725 |
| AVL | | | | | (.232) | (.099) | (.144) | (.526) |
| | | | | | | | | * |
| | | | | X | .039 | -.192 | .351 | .510 |
| RVL | | | | | (.002) | (.037) | (.123) | (.260) |
| | | | | | | | | |
| | | | | | X | | -.012 | .204 |
| ACMS | | | | | | | (.001) | (.042) |
| | | | | | | | | |
| | | | | | | X | -.020 | .043 |
| RCMS | | | | | | | (.001) | (.002) |
| | | | | | | | | |
| | | | | | | | X | |
| ADT | | | | | | | | |

* = significant at the .01 level
** = significant at the .001 level
Empty boxes represent values already related by definition

VIRS = Visual Impact Rating Score
TCA = Total Camp Area
PBA = Percent Bare Area
AVL = Absolute Vegetation Loss
RVL = Relative Vegetation Loss
ACMS = Absolute Change in Mineral Soil exposure
RCMS = Relative Change in Mineral Soil exposure
ADT = Absolute Damaged Trees
PDT = Percent Damaged Trees

Absolute vegetation loss not only seemed to represent loss of overstory and understory plants, but also correlated well with soil conditions. These results indicate that there is a relationship between absolute vegetation loss and the percent bare area. An explanation of this involves examining the sampling method used. First, there is an inverse relationship between percent of bare area and the total camp area (i.e., the larger the sites, the smaller the percentage of bare ground). Likewise, smaller campsites had a larger percentage of their total area bare. This situation is a byproduct of the weakness of the camp area measurement discussed above. Second, as explained in the methodology, the number of sample quadrats corresponded with the size of the camp area. Therefore, on smaller sites a greater number of samples were probably taken within the bare area. Consequently, differences between campsites with larger percentages of bare area and their corresponding controls would be greater than campsites which had smaller bare areas, and thus, more samples taken in the bare area.

A more accurate indicator of soil conditions is the change in mineral soil exposure. Unlike the percent of bare area, changes in mineral soil were monitored on both campsites and controls. A sizable portion of the estimates of mineral soil consisted of bare rock exposures. The significance of this positive relationship between absolute vegetation loss and absolute change in mineral soil exposure is twofold. First, reduction of vegetation cover increases the vulnerability of the A horizon to compaction and erosion. Secondly, the exposure of parent material beneath the soil profile, which is already widespread, also increases as plant cover is removed.

As with the overall rating score, absolute vegetation cover was strongly related to the percentage of damaged trees. In fact, this was the highest statistical correlation among all indicators. This implies that similar use patterns affect ground cover and overstory in the same manner. For example, if large parties are more damaging to plant cover, they seem to have a concurrent affect on tree scarring. Or if horse groups over-trample campsites, at the same time they do proportional amounts of damage to tree roots and trunks. Though these are mere conjectures, a strong link between these parameters is evident, and may merit further investigation in future studies.

A final relationship of significance is that of absolute mineral soil exposure and percentage of bare area. This correlation simply suggests that increases in bare area correspond to exposure of soil on the campsite as a whole. Since percentage of bare area is greater on smaller sites, more sampling was probably done within this bare area, hence the greater the amount of mineral soil exposure.

Another means by which the relative strength of indicators may be judged is by looking at differences in impacts incurred at varying levels of use and altitude.

## Comparison of High and Low Use Campsites

Possible differences between impacts incurred on high and low use campsites were evaluated by means of the Student's t distribution, or t-test (Blalock 1979). Aggregate values of high use were compared to those of low

use campsites for each impact indicator (see Table 3.2). Significance of differences, if any, were checked and levels of significance assigned by comparing answers with table values (Blalock, p.603). At least a .01 level of significance for a one-tailed test was needed for impacts at high and low use levels to be considered statistically different. The test was set up in such a way that positive values indicated significantly greater impacts on high use campsites versus low use campsites.

Table 3.2 t-Test For Differences Between Use Levels

| Indicator[1] | t-Score | Significance level | Table Value* |
|---|---|---|---|
| VIRS | 3.35 | .005 | 3.055 |
| TCA | .586 | no significance | ----- |
| PBA | -.87 | no significance | ----- |
| AVL | .99 | no significance | ----- |
| RVL | 3.69 | .005 | 3.055 |
| ACMS | .13 | no significance | ----- |
| RCMS | .46 | no significance | ----- |
| ADT | .73 | no significance | ----- |
| PDT | 1.47 | .10 | 1.356 |
| RVL+RCMS+PDT | 1.66 | .10 | 1.356 |

* degrees of freedom = 12
[1] An explanation of indicator acronyms is found in Table 3.1

Only two of the nine indicators, VIRS and relative vegetation loss, revealed statistically significant differences associated with use. Percent damaged trees showed some difference, but not at a statistically significant level. Differences between use levels for the other six indicators were either nonexistent or negligible. While it is assumed that impacts increase with use, differences between use levels appear to be modest.

In an attempt to test the robustness of the VIRS as a measure of campsite conditions, a combined value of relative vegetation loss, relative change in mineral soil exposure, and percent damaged trees was tested to see if it differed between use levels (see Table 3.2). In theory, this combined value represented the various components of the VIRS, minus the "Other" category. The result of this test was that the combined indicators revealed some difference, but not at a significant level. This was not surprising given the very low t-score of relative change in mineral soil exposure and the weight allowed for aesthetic conditions in the VIRS.

First, in looking at mineral soil, this result seem to agree with Merriam, et al., (1973). They discovered that soil conditions changed very little after the first few years use (i.e. after light use).

Second, the "Other" category within the VIRS consisted largely of aesthetic conditions. That is, indicators of impact which are viewed as qualitative blemishes on the campsite's appearance. In many instances, these impacts are not of an ecological nature, and therefore may be easier to correct. Examples of aesthetic impacts are presence of litter and feces,

construction of seating and bedding fixtures, or large fire-charred boulders and logs.

The measurement of aesthetic conditions made up a full 25% of the VIRS, which may have accounted for differences with the combined objective value in itself. In this respect, the VIRS seems to have accomplished its purpose of combining both the objective and the subjective aspects of campsite conditions. As a result it is hoped that both the manager's and the user's priorities are represented.[1] With this aesthetic component in mind, the VIRS does seem to be a fair representative of campsite conditions as use increases.

Other than the VIRS, the best representative of differences between use levels was relative vegetation loss. As use increased from light to heavy, vegetation which is either sparsely scattered across the site, matted down, or protected by some feature (i.e. boulder, log, standing tree or shrub) becomes trampled. Furthermore, trampling near trees may coincide with the increases in percent of damaged trees. This seems especially true when considering increases in horse use, as well as human use. Sites with intensive root damage and trunk scarring are more likely to have been heavily used by horse groups (Cole 1983, p.9).

## Comparison of High and Low Altitude Campsites

A t-test was also used to see if campsite conditions in subalpine forests and lower montane forests differed significantly. Aggregate values from high elevation sites were compared to those at low elevations. Possible differences were tested using all nine impact indicators. Once again, calculated values of .01 significance level or lower were needed to be considered valuable. Significant relationships were found in five of the indicators: total camp area, percent bare area, absolute vegetation loss, relative vegetation loss, and percent damaged trees (see Table 3.3). Only two of the indicators revealed no statistically significant relationships.

The relationship between total camp area at high elevation versus low elevation is highly significant. However, the inverted nature of this relationship merits a critical look. Camp areas were larger at lower montane sites than at subalpine sites. The worth of this indicator, however, is questionable. Lower altitude campsite parameters were often difficult to delineate because of sparse ground cover throughout the area; consequently, their sizes were distorted.[2] At subalpine sites, where ground cover was

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1. While I think that managers are genuinely concerned with both the ecological an the aesthetic appearance of campsites, user's often focus their attention primarily on such matters as the litter or feces left by previous parties (Stanky 1980; Deans 1979).

2. The three largest campsites were found in low altitude/low use areas, with the most sizable being 3,167 ft.$^2$ (mean area value 1,655 ft.$^2$). The biggest site on a high altitude/high use site was 2070 ft.$^2$ (mean area value 1088.91 ft.$^2$). Individual campsite values for all indicators can be found in appendix III.

Table 3.3 t-Test For Differences Between Altitudinal Zones

| Indicators[1] | t-score | Significance Level | Table Value* |
|---|---|---|---|
| VIRS | 1.94 | .05 | 1.78 |
| TCA | -3.59 | .005 | 3.055 |
| PBA | 2.96 | .01 | 2.681 |
| AVL | 6.04 | .0005 | 4.318 |
| RVL | 13.38 | .0005 | 4.318 |
| ACMS | 1.54 | .10 | 1.356 |
| RCMS | .52 | no significance | ----- |
| ADT | -.32 | no significance | ----- |
| PDT | 2.684 | .01 | 2.681 |

* degrees of freedom = 12

1 An explanation of indicator acronyms is found in Table 3.1.

dense, campsite perimeters were more distinct. One possible solution to this dilemma might have been to reduce the minimum vegetation cover to 5% to separate camp from non-camp areas. In an effort to reduce the area of sparsely vegetated campsites, however, the size of sites which have heavy vegetation cover would be reduced as well. Many subalpine campsites had 5-10% plant cover on the trampled portion of the site itself. It is because of this problem of measurement that total camp area is not given much value as an impact indicator. A uniform-sized camp plot, as Fichtler (1980) employed, would avoid this problem but it may either under-represent or over-represent impact conditions on campsites of different sizes.

Another significant indicator of differences between subalpine and lower montane campsites is percent bare area. In habitats where there is little vegetative cover, loss of duff may provide a clearer sign of trampling than measures of vegetation loss. Unfortunately, bare area was used only as a percentage measurement of the total camp area. Where camp areas were very large and bare areas moderate to small, a relatively low percent of bare area was recorded. In fact, this was the case in many lower valley campsites. Because of the problems associated with total camp area, measures of bare area, which were based on total camp area, were likewise distorted. Had a total bare area been recorded, a more accurate picture of this relationship may have appeared.

On the other hand, impacts on vegetation revealed pronounced differences between altitude locations. Loss of vegetation cover, both absolute and relative, was significantly greater on subalpine campsites than on lower valley sites. In fact, their t-scores easily exceeded the highest table values. This suggests highly significant differences in loss of vegetative cover between the two zones. An immediate reaction might be to say that subalpine sites have much more vegetation to lose, and therefore their high absolute losses are justified. This does not seem to be the case, however, given the extremely strong relative, as well as absolute, loss.

A final significant indicator was percent damaged trees. Though differences here are not as strong as those produced with ground cover, a marked dissimilarity does appear to occur between altitude levels. Types of

damages were similar in both the upper and lower altitude settings. In the lower montane zone many more trees were present around campsites; conversely, in most cases, there were fewer trees to damage at higher campsites. This situation may be viewed in two ways. If there are more trees at lower sites, than there are more to damage. On the contrary, if similar numbers of trees are injured on high and low altitude sites, but fewer trees exist at upper elevation sites, than percent values will be higher on subalpine sites. This explanation seems more plausible given the t-value calculated for absolute tree damage. Visually speaking, damages may appear greater in the long term at upper elevations. This all depends on how rapidly the individual species can recover from root, trunk, and crown scarring, however. Responses of tree species will be discussed in a separate section below.

The VIRS and absolute change in mineral soil exposure showed a weaker relationship between altitude levels. They are only mentioned here to emphasize the greater consistency of differences between campsites at high and low elevations than between use levels. A more complete discussion of this overall relationship will follow the consideration of specific habitat and species types.

## Discussion of Habitat and Species Responses to Impacts

### - Understory

As discussed earlier in reviewing previous studies, a number of works have attested to the abilities of alpine and subalpine meadow communities to resist trampling damages. But once impacts are incurred, how well do forested ecosystems recover? Persistent and sizable differences between control-campsite pairs implies that little regrowth has occurred once original cover has been decimated.[3] Data presented here suggests that both absolute and relative vegetation losses are significantly greater in forested subalpine communities (Picea englemannii/Vaccinium scoparium and Abies lasiocarpa/V. scoparium) than in forested lower montane communities (Pinus contorta/Juniperus communis and P. contorta/Berberis repens). This seems to confirm earlier observations that ability to recover decreases as growing season decreases (Ceislinski and Wagar 1970; del Moral 1979). Furthermore, del Moral stated that areas of high ground cover with wet, sloping soils are most vulnerable to trampling (p.297). In many instances, these conditions typified subalpine campsites.

In contrast, Cole (1979) found that "open forests" were less prone to trampling damage than dense forests. He found that reduction of ground cover in dense Pinus contorta/Vaccinium scoparium forests, for example, was significantly greater than cover reduction in Pinus albicaulis/V. scoparium open forests. In the present study, habitats with a dense overstory proved to be more resistant.

Another important issue is the ability of more resilient species to

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3. Thornburgh (1962) found that regrowth of vegetation at Image Lake, in the north Cascades, was very limited even 20 years after intensive grazing by sheep was prohibited.

establish themselves on campsites after initial use. Coombs (1976) found that the number of species tended to increase slightly with light use, then decrease with further use. In looking primarily at low use backcountry campsites in Idaho, she discovered that some species seem to take advantage of disturbances. Coombs, and others (Cole 1982; Thornburgh 1962), found that resistant plants were present in small proportions on untrampled control sites and larger proportions on campsites. In following this logic, some observations about species on Uintas' campsites can be made.

Overall, the variety of plants found on higher and lower sites was about equal (see appendix II ). However, most individual sites in subalpine locations had a greater species diversity. The most common species on these sites were Vaccinium scoparium, Achillea millefolium, Antennaria alpina, and Poa nervosa. On most lower valley sites, fewer species were recorded as being common at individual campsites. Most sites under dense P. contorta presented only one or two understory species in abundance. Overall, however, the number of common species were about equal between elevational zones because a couple of lower valley sites exhibited greater diversity. The most common species on lower sites were Juniperus communis, Berberis repens, and Poa secunda.

If we examine these species in terms of their morphological characteristics some interesting conclusions may be drawn. For example, Holmes (1979) suggested that tall plants which are entirely herbaceous and have lateral stem shoots evenly distributed, typify the most vulnerable species (p.85). Achillea millefolium is a plant which meets these standards, and was sparsely scattered on many subalpine campsites, implying great losses in cover. Strangely, though, this plant was often sited in unprotected locations, suggesting that it does bare some resilient qualities.

In accordance with this, Holmes cautions that plants of the same communities and growth forms may have differing survival rates (p.87). To illustrate this, let us examine another plant common to subalpine campsites; Antennaria alpina. Cole (1982) found this forb to be a "decreaser", that is, one which was found in greater relative quantities on control sites than on campsites. Holmes, on the other hand, found the same plant to have a fairly high (70%) survival rate as compared to other common subalpine plants (p.87). Additionally, Smith (1979) described A. lanta, a related species, as a strong indicator of recovery on severely damaged sites. The presence of A. alpina on sites in the Uintas, given my results, tends to agree with Cole's observations. It was observed in a dense turf around campsites, but only sparsely scattered on the sites themselves.

A final common subalpine species, Vaccinium scoparium, is short in stature and has a woody stem. Many sources seem to agree that woody stemmed plants, especially V. scoparium, are the least resistant to trampling (Cole 1979, 1982; del Moral 1979; Fichtler 1980; Holmes 1979), and in addition, take much longer to regenerate (Campbell and Scotter 1975). In the Uintas, sites where V. scoparium was present showed greater losses of plant cover as well. The presence of this species in abundance in subalpine forested areas may explain the large losses of vegetation on sites located in this zone.

Juniperus communis, a woody shrub, presents a different picture. Its rate of loss did not seem to be as severe as that of woody subshrubs like Vaccinium scoparium. But, the survival rate of J. communis may be credited more to its location than to its ability to "resist" trampling. This shrub

was most often found in protected sites, such as under tree crowns or behind large boulders, on both campsites and controls, hence its ability to survive. Regardless, J. communis made up a sizable portion of understory growth on low altitude sites.

Berberis repens, on the other hand, appeared to grow continuously in unprotected sites. Losses of this species seemed more pronounced than Juniperus communis because of B. repens abundance on controls and scarcity on campsites. While Cole (1979) argued that erect, woody plants in shaded areas were poorly suited to trampling, my findings were that the responses of individual woody species differed greatly. Perhaps the species in his study were not as protected as J. communis. At the same time, the reaction of B. repens to campsite trampling seems to confirm Cole's findings.

Poa secunda, on the other hand, seemed to show little change from surrounding areas to campsites. This plant was often the only species observed on the heavily trampled portion of low altitude campsites. Schreiner (1974) attributes the ability of graminoids to survive in trampled areas to their having buds which are located beneath the ground surface and thin, flexible leaves. In addition to these resistance mechanisms, the dispersed location of grasses on Pinus contorta sites may also have assisted their survival. Poa nervosa was the most common species found on subalpine sites, but from the data presented, it appears as if its relative losses were greater than P. secunda. While P. nervosa was densely matted on control sites, it was only sparsely growing in patches on campsites. More detailed study of plants of the same genus in different habitats is probably needed before precise conclusions can be reached.

- Overstory

Little work has been done to rank or compare tree species in their responses to recreation impacts. It is assumed here that if ground cover species respond differently to trampling, then overstory species will have varied responses to scarring as well. For example, scarring of trees may increase their susceptibility to fungal attacks (Cole and Dalle-Molle 1982). Ripley found that conifers around campgrounds were more susceptible to disease than hardwoods, although he provides little data to back this. Mechanical injuries to Populus tremuloides produced severe instances of cankers and fungal attacks in Colorado campgrounds (Hinds 1976). Similar scarring and disease appeared on P. tremuloides on a heavily used campsite in the Uintas, as well. The result was a decrease in the vigor or death of many of the P. tremuloides on this particular site. Furthermore, the weakening of trees by scarring and disease increases their susceptibility to windthrow (Nelson 1963). The results presented in this study suggest that tree species react differently to recreation impacts, and therefore, certain species may be more prone to these types of permanent damages.

The dominant overstory at subalpine sites on the south slope of the Uintas are Picea englemannii and Abies lasiocarpa. Lower valley sites consisted of mostly Pinus contorta overstory. It has been suggested by Cole and Dalle-Molle (1982) that ecological impacts will be more pronounced where less wood is available for campfires. The high percentage of tree damage at subalpine sites in this study seems to confirm this observation. However, no

studies have been done which directly compare responses of recreational impacts to these species.

Yet, there are two studies in which results may be applicable to this discussion at the genus level. The first was a project to monitor the degradation of new campsites in the Boundary Waters Canoe Area (Merriam, et al., 1973). After five years, they found a greater percentage of trees dead or with exposed roots on sites with Picea sap.[4] and Abies balsamea than on those with either Pinus banksiana or P. strobus and P. resinosa. Furthermore, they noted that "...shallow rooted spruce-balsam fir types also showed tree loss to windthrow and visitor damage." (p.25).

A second study revealed similar conclusions concerning the resistance of species to recreational impacts in the northern Cascades of Washington. Del Moral (1979) developed a species resistance index in which he found Pinus albicaulis to be more resistant to degradation from camper scarring than both Abies lasiocarpa and Larix lyallii. All tree species he evaluated were at the subalpine level. Both of these studies, in conjunction with results presented here, suggest that Picea sap./Abies sap. are more likely to show signs of recreational impacts for longer periods of time than Pinus sap..

## Discussion of Results

From the evidence presented above we are now in a position to discuss the three questions posed at the beginning of this chapter. In summarizing tables 3.1, 3.2, and 3.3, the relative strength of impact indicators may be judged. Measures of vegetation loss, tree damage, and the VIRS consistently revealed strong relationships, both with other indicators, and as a means of showing differences between use levels and altitudinal zones. Among these, relative vegetation loss was the strongest measure. However, the VIRS and percent damaged trees also proved to be useful indicators, while their acquisition required much less time.

In examining differences between use levels I would like to refer back to figure 1.1, in which Cole (1982) presented a model for incursion of impacts with increasing use. If the assumption can be made that use levels presented here roughly equal those presented by Cole, then a similar relationship appears to exist in both studies. That is, differences in impacts between use levels are relatively minor compared to differences between lightly used sites and control sites. These relationships also mean that much of the total impact occurs with light use, and increasing intensity of use adds relatively little impact.

There were few impact indicators which showed strong differences between use levels, though relative vegetation loss and the VIRS were remarkably different in this respect. These results suggest that differences that do exist between use levels are highly weighted toward vegetation and aesthetic degradation. Aesthetic impacts were only accounted for in the VIRS. This

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4. Specific spruce species names are not given in this study. The sources I have checked list P. glauca and P. mariana as common spruce trees in northeastern Minnesota.

aesthetic component consists largely of the visual impacts which cannot be quantified, but which may detract from the appeal of the campsite (e.g. litter, feces, charred logs and rocks, excessively large firepits, construction of seating and bedding facilities). Since they made up a large percentage of that score (25%), aesthetics seemed to have significantly influenced the difference between the VIRS and the aggregate objective measurement. From the visitors perspective, at least, these qualitative factors may provide a better measurement of the differences between use levels. This aesthetic component may be superimposed onto the graph of conventional objective measurements as shown in figure 3.1. Camp aesthetics are represented by a dashed line because, similar to the relationship between impacts and light use, further work is needed before more concrete conclusions can be drawn. However, the importance of this factor should not be discounted if this representation is a valid one. For many wilderness users, campsite aesthetics may be a critical part of their outdoor experience. If this is true than research on campsite impacts should reflect this aesthetic aspect.

Nevertheless, when taking into account all indicators, differences between use levels were relatively minor, as the solid line in figure 3.1 suggests.

In comparing impacts between altitudinal zones, clearly a different picture is presented. A majority of the impact indicators revealed significant differences between zones. Only one of these indicators, total camp area, showed a negative relationship. That is, low altitude campsites were larger than high altitude campsites. The serious problems with the logistics of measuring camp area seem to invalidate it as a reliable indicator. Still, four values were statistically significant in the positive direction (i.e. greater impact at subalpine sites), and at least two others revealed some positive relationship.

With this in mind, I would like to present a model similar to that given by Cole, but in which amount of impact is correlated with increases in altitude (see figure 3.2). The X axis represents an elevational progression from a forested valley, to a forested subalpine basin, to an alpine meadow: Impacts increase with altitude to a point somewhere below treeline. Since alpine meadows were not evaluated here, this portion of the graph was inferred from previous studies which attest to the ability of meadow communities to resist recreational damages (Roemer 1975; Cole 1979, 1982, 1985; Schriener 1974; Fichtler 1980; Weaver, et al., 1979; Holmes 1979). Though there are obviously grasslands and meadows below treeline, they are not evaluated here. However, meadows below treeline may be similar to alpine vegetation and therefore grouped with areas to the right of the treeline divide in the figure. It is, therefore, my conclusion, that of the forested habitats studied here, subalpine communities seem to be more prone to campsite impacts than lower montane communities. Meadows may be more resistant to camping use although this relationship needs study.

Finally, the question of how well these relationships portray actual responses to environmental differences arises. Is the above conclusion a product of inherent weaknesses in subalpine ecosystems, or do other factors account for the differences in impacts?

Figure 3.1 Relationship of Aesthetics to Amounts of Use

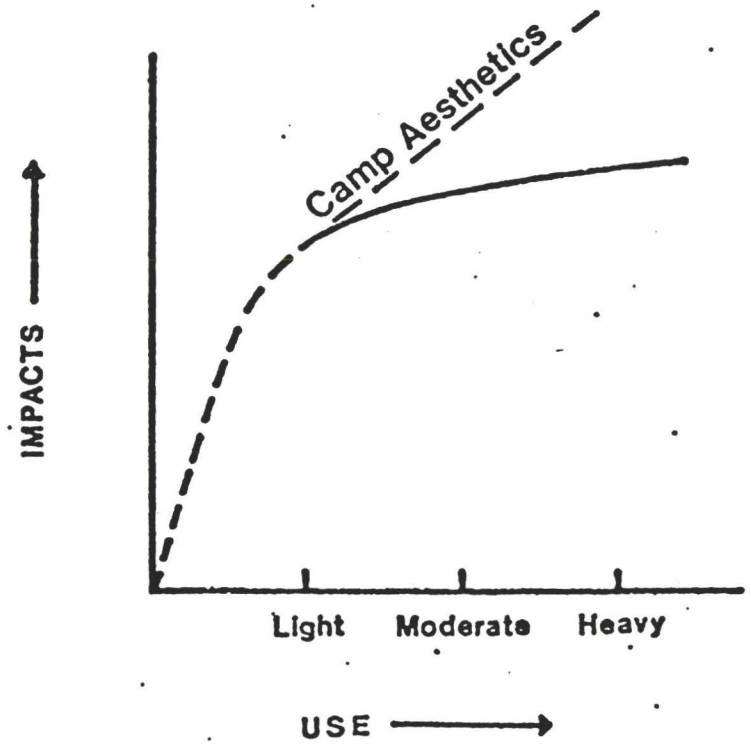
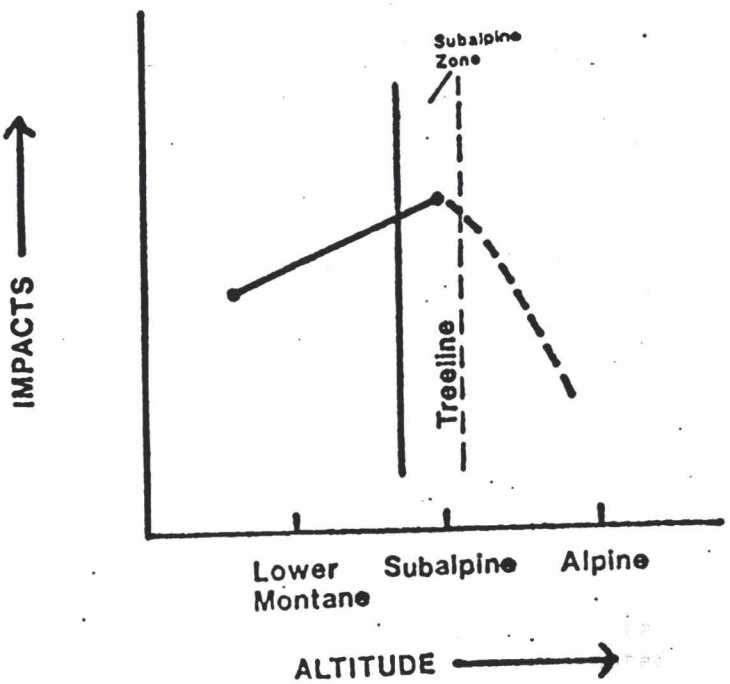



Figure 3.2 Relationship of Impacts to Altitude



For example, one factor that has not been discussed is the duration of stay at subalpine sites versus lower montane sites. At first glance it appeared as if visitors stayed longer at so-called "destination sites", such as those around subalpine lakes. In fact, this is true. But more people stay at individual valley sites, even if for only one night, because they are concentrated along access routes. The result is a situation in which people stay longer (i.e. more than one night) in more dispersed subalpine campsites and a shorter period (i.e. one night or less) in concentrated valley sites. This tends to balance the number of user nights out, but it may lead to differences in the physical appearance of campsites.

A related factor is the difference in the aesthetics of campsites and their relation to varying forms of use between destination sites and temporary sites. People tend to make greater alterations to campsites in which their stay will be longer in an effort to make them more "comfortable". Many subalpine sites, especially in high use areas, had elaborate seating, shelter, and campfire fixtures. At the same time, lower sites seemed to have more on-site garbage. Perhaps people who made use of sites for a day or less were less conscientious about campsite clean-up upon departure, although this is an easier problem to confront than large scale alterations. Clean-up crews may periodically pick up garbage on sites, but the building of campsite fixtures often incorporates direct maiming of the physical surroundings (e.g. felling trees, removing boulders, digging drainage trenches around tent sites). Though these are merely personal observations, it stands to reason that a greater understanding of how use patterns affect site degradation would be of importance in future studies of this type. Unfortunately, this was beyond the scope of the present study.

In short, I have proposed a generalized scheme of environmental response to camping as altitude increases. Further, I have confirmed the observations found elsewhere, that increases in impacts from low to high use are minimal compared to those incurred with initial use. In terms of impact measurement, loss of vegetation, tree damage, and an overall visual rating of campsite conditions, seem to be the most reliable indicators. The next logical step is to work the information gained here into an overall system of optimum campsite location. This is the intent of the following section.

## Section 4 - MANAGING BACKCOUNTRY CAMPSITES FOR MINIMUM VISITOR IMPACT

In this section, I will present a framework for determining minimum impact conditions, using the variables of moisture, slope, use, and habitat as it is affected by elevation. Following this will be a discussion of management implications. In the last section I will make some concluding remarks.

### Minimum Impact Conditions for Backcountry Recreation

It is commonly believed that the cause of extreme campsite degradation is excessive use. In fact, it has been shown here, and elsewhere (Cole 1982; Fichtler, 1980; Merriam, et al., 1973; Dotzenko, et al., 1967), that impacts increase only slightly from light use to heavy use. Instead, it seems that the environmental characteristics and use patterns of specific campsite locations are more important in determining susceptibility. If managers and visitors are made aware of possible damage-prone campsites, steps can be taken to deter the use of such areas. With this in mind, I will examine each of the following variables in an attempt to identify the optimum conditions for minimizing recreational impact.

- Moisture

Moisture content of soils vary considerably. Sites found in or near depressions or seasonal runoff channels, may become saturated during periods of snowmelt or high precipitation. On the other hand, ridges or areas with well drained soils are more commonly dry. While Holmes (1979) argues that plants are more susceptible to damage under dry conditions, others have described wet periods as times during which vegetation is most easily damaged (Willard and Marr 1970; Trottier and Scotter 1973; Kucher 1972; del Moral 1979; Brown and Shomaker 1974; Roemer 1975). Managers can hardly be expected to discourage use on all sites during wet weather, but if users were made aware of the consequences of their camping activities, campsites which are adjacent to runoff channels or late lying snowbanks might be avoided and thereby protected.

In addition, moisture in combination with sloping terrain may be especially serious. For example, three campsites on the heavily used Upper Chain Lake (sites 13, 14, and 15) were situated on sloping terrain very near the lake shore. These sites exhibited excessive erosion as a result of runoff where vegetation was either totally or partially removed. On such sites camping should be generally prohibited.

- Slope

Generally, the greater the incline of the ground surface, the higher the potential for impact. Both Weaver, et al., (1979) and Holmes (1979) found that trampling on slopes resulted in greater damages because of the increased friction between the trampler and the ground. Holmes further noted that

> Ripping and topographically induced gouging plays a small role in trampling impact in the normally flat camp areas; however, their impact is substantial on slopes or at embankments such as near the edges of streams or lakes. (pp.84-85).

This observation was further confirmed by my results which contrasted the differences between high and low altitude sites. Lower montane campsites were located near streams, but often on flat, dry ridges above the streams. On the other hand, a few subalpine sites ( i.e. those mentioned above) were found on sloping lakeshores, hence their greater amount of vegetation loss. Additionally, these sites often exhibited runoff channels etched into the mineral soil, suggesting greater soil movement. With these campsites close to lakes, moreover, contamination from camper waste products could be transported via the erosion channels into the water supply.

- Use

It would be very difficult, and probably not worth the effort, to determine the absolute amounts of use which produce given amounts of impact, given the evidence that differences in impacts between most use levels are slight. A more fruitful approach is to examine differences characteristics of use. If certain locations promote forms of camping which are more harmful to the environment, then efforts could be made by managers to either relocate campsites or alter the harmful practices which take place on those sites.

As an illustration of this idea, three use characteristics will be examined: duration of stay, mode of travel, and use of campfires. Earlier, I suggested that in the Uintas, people seemed to alter subalpine sites more than lower elevation sites because they tended to stay longer at high elevation locales, and people seemed interested in creating greater comforts at such sites. In contrast, short-term convenience, rather than long-term comfort, seemed to explain the fewer alterations (e.g. rocks and logs moved for seating) at lower valley campsites.[1]

As regards modes of travel, observations made here, and study results elsewhere (Cole 1982, 1983(b); Weaver, et al., 1978), strongly suggest that horse parties cause greater damage that hikers. Since horse parties can travel farther in a day, and they prefer trails with moderate inclines with few obstructing boulders, their destinations are somewhat limited. In addition, unless feed is packed in, horses will need some area for grazing; this further limits the destination of horse parties. In the Uintas, moreover, visitors with stock animals tend to move into subalpine sites without intermediate stops at lower sites. Thus, taken together, the areas which horse groups utilize receive heavy use, which compounds the general tendency of horses to inflict greater impact than hikers.

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1. An analogy may be drawn here between camping and overnight accommodations. One is likely to make few alterations in a motel in which he/she is staying for a single night. However, more significant adjustments would be made, in the name of comfort, if he/she stayed at a friend or relative's house for a week. Still more adjustments would be expected if the stay were a year or two.

Finally, the use of wood for campfires obviously puts more demand on ecosystems, especially where there are shortages of combustibles. The supply of wood may be limited in areas where campsites have experienced exceptionally heavy use, or where there are initially fewer trees and shrubs, such as in subalpine forests or meadows. In these cases, availability of wood, and consequently the use of campfires, is also limited spatially by location.

In all of these use characteristics, potentially destructive activities may alter the areas where they occur. They should be given greater weight, perhaps with other, as yet undefined, use characteristics, than simple numbers of users. However, more research is needed to determine the affects of different use patterns before any final recommendations can be made.

- Habitat

The subject of habitat susceptibility, as it changes in a general sense with altitude, has been discussed throughout this paper. I have suggested that forested habitats increase in their susceptibility to impacts up to a point somewhere in the forest - alpine ecotone, and then impacts decline sharply as overstory changes to meadows (see figure 3.2). With this in mind, campsites would probably create fewer environmental alterations if they were located either in lower elevation forested habitats or in subalpine and alpine meadow communities. Underlying these recommendations is the assumption that campsites be situated on a relatively level, dry surface.

It should be kept in mind that this is not a complete biotic perspective. The focus here is one of maintaining the vegetative cover and aesthetic appearance of campsites. In specific localities, other factors, such as wildlife preservation, species diversity, or general landscape appearance, may take precedence over the visual appearance of campsites. However, maintenance of a ground cover, even at the expense of species diversity, will prevent further damage to soils in the form of compaction and erosion. Moreover, it is the visual aspect of campsites which most visitors and managers evaluate. There may be need to analyze not only the vegetation and soil of campsites but the impacts of campsite location on larger ecosystems and human perceptions of wildness in landscapes.

## Management Implications

Now that I have identified some spatial factors which may affect the susceptibility of environments to campsite impacts, I would like to turn to a final topic: a system for monitoring and minimizing campsite impacts. In compliance with the Wilderness Act (U.S. PL 88-577, section 4b) administrators of designated wilderness areas are required to manage these areas in such a way as to preserve "...the wilderness character of the area...". In monitoring wildlands, however, managers often are not equipped to undertake intensive physical and social surveys of backcountry conditions. This is due mainly to lack of personnel and funding to initiate such projects. What is needed is a simple, but efficient, means of monitoring campsite (and trail) conditions periodically so that certain types of use can be eliminated in areas of stress.

A framework for monitoring wilderness conditions, called the Limits of

Acceptable Change (LAC), is provided by Stankey, et al., (1985). Generally, the LAC is a system designed to allow managers to decide the conditions which are acceptable to their specific situations, and then to prescribe actions to preserve those conditions. More specifically, the authors outline four major components of the system as:

1. The specification of acceptable and achievable resource and social conditions, defined by a series of measurable parameters.

2. An analysis of the relationship between existing conditions and those judged to be acceptable.

3. Identification of management actions necessary to achieve these conditions.

4. A program of monitoring and evaluation of management effectiveness. (p.3).

I would like to use these four components as a foundation for applying the findings and recommendations developed here.

In specifying acceptable and achievable conditions of environmental impact, reliable impact indicators should be cost-effective and accurate, show a relationship to amount and/or type of use, relate to user concerns, and be responsive to management actions (Stankey, et al., 1985, p.10). The most consistent indicators used in the present study were relative vegetation loss, percent damaged trees, and the VIRS. These three indicators might be used to initiate management responses in order to protect campsite impacts.

Relative vegetation loss between campsites and controls was the most accurate measure of differences in impact, both between use levels and altitudinal zones. Many campsites had between 60 to 90 percent relative vegetation loss. An achievable goal would be to set an upper limit of 95 percent relative loss, and monitor closely those sites which are between 85 and 95 percent loss. Severely damaged campsites should probably be closed temporarily or permanently to allow for regrowth of ground cover.

A second measure of campsite impacts, percent damaged trees, proved to be reliable, as well. In terms of measurable parameters, campsites with 25 percent, or more, of their trees injured or scarred should be closely monitored. If greater than 40 percent of the trees have been damaged, within a 50 foot radius, closure of the campsite should be seriously considered.

A final reliable measure of campsite impacts was the VIRS. As an overall condition rating, it seemed to represent both measurable parameters (i.e. ground cover, tree damage, soil conditions) and aesthetic indicators. An acceptable limit to overall conditions could be set at a VIRS of 15. Sites that have a VIRS rating of greater than 15 should be examined to determine further management actions. In addition, a watchful eye (i.e. inventory at least once a year) should be kept on sites with VIRS's within the 12 to 15 range.

In reference to the measures of reliability given by Stankey, et al., (1985), all three of these indicators are accurate, relate to amount and type

of use, and are responsive to management controls. However, the VIRS is the most cost-effective, and probably best relates to user concerns.

Once impact indicators have been selected, the limits of acceptable change for each indicator should be compared to actual campsite conditions. In this data gathering phase of the LAC system, emphasis should be placed on consistency in field techniques so that results can be reliably compared between all sites. If possible, a map of all sites should be maintained as an ongoing record of their conditions.

The third major component of the LAC model is to identify the actions necessary to achieve the desired conditions. These actions will depend on the weight given to indicators employed. Since aesthetic impacts, in most cases, are easier to correct, they may not be given the weight of ecological conditions. Severe ecological impacts could warrant the closure of sites immediately. If sites are closed to visitor use, greater stress will be placed on adjacent campsites. In cases where concentrated damages are occurring, users should be directed to either less susceptible locations, or to areas with lighter use and impacts.

In all cases of management actions, users should be informed, before they enter the wilderness setting, of where these sensitive campsites are, and why they are currently not open to use. At the same time, visitors could be further educated about the camping techniques which lead to severe damage. Washburne and Cole (1983, p.9) stated that over one-half of the areas in the National Wilderness Preservation System[2] have some type of minimum impact education programs. However, the effects of education on redistribution of visitors is highly variable (Lucas 1981), and it seems to be regionally limited (Washburne and Cole 1983, p.9). In the High Uintas Wilderness Area, on the south slope at least, there is no program of minimum impact camping. In all cases, expansion and improvement of education in minimum impact techniques may be a vital contribution, if reduced abuse of wildlands is desired.

The final component of the LAC, a program for monitoring management effectiveness, is essential for maintaining the desired conditions. Using the indicators discussed above, various monitoring approaches can be considered. The most desirable is to maintain an ongoing system in which a large variety of indicators are used to measure soil, understory and overstory vegetation, and visual conditions. Unfortunately, in this study, a reliable measure of soil conditions was not found[3]. Moreover, extensive ecological surveys for all campsites often are not feasible. In cases where funding is limited, at least two alternatives drawn from this study are possible. The first would be to make a visual assessment of all campsites annually, using a measure such as

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2. The National Wilderness Preservation System is composed of four agencies which preside over designated wilderness areas. These agencies are the Forest Service, National Park Service, Fish and Wildlife Service, and Bureau of Land Management.

3. Suggestions for other measures of soil conditions may be found in Thornburg (1962), Dotzenko, et al., (1967), Merriam, et al., (1973), and Cole (1979 and 1982).

the VIRS, and more empirical measurements every 2 to 4 years. A similar approach is to monitor all sites annually with the VIRS, and also obtain measures of relative vegetation and/or percent damaged trees on all sites which have VIRS's greater than 12. This latter proposal will focus more attention on sites that are nearing a critical stage of impact.

An integral part of this ongoing process should be to look for new methods which could possibly improve or supplement the existing system. With continued research, more efficient management strategies can be explored.

## Conclusion

It has been my goal in this study to explore the responses of environments to human use in a backcountry recreational setting. Many interesting conclusions were reached.

First, measures of vegetation loss, tree damage, and overall visual impact seem to respond similarly to changes in use and altitude. Separately, the strongest impact indicators in all tests were those of vegetation loss. Percent of damaged trees and the VIRS were also consistently significant, but an additional advantage of these two indicators was the relative ease with which they could be measured or evaluated. In general, there was consistency between the strength of indicators when correlated with each other and as a means of showing differences between both use and elevation levels.

Second, differences between high and low use levels were less than the dissimilarities between altitudinal zones. The only significant differences between use levels were those of relative vegetation loss and the VIRS, suggesting that understory and overall visual degradation are most sensitive to increasing amounts of use. Still, in light of all the variables tested, it appears as if most impact takes place upon initial use, and then increases slowly with higher use.

Third, the differences between altitudinal zones were strong: most indicators produced at least some statistical relationship with elevation, and four of the nine indicators showed significantly greater damages at subalpine campsites. Thus, subalpine forested communities seem to incur greater damages than lower montane forests with similar amounts of camping activity.

Finally, the results found in the Uintas may not apply in precisely the same manner to other locales. Yet, the same techniques as those used here, particularly the VIRS, can be of benefit to both users and managers elsewhere.

The more that users and managers know about recreational impacts, the better equipped they will be to minimize the alteration of natural areas. With information on environment-impact relationships, managers can educate the public and initiate more efficient management policies. Though some users may feel that increased management is an infringement on the character of wilderness recreation (Wuerthner 1985), a majority seem to agree with regulation once they are informed of its purpose (Bultena 1981). It should be kept in mind that even though use of wilderness promotes an independent spirit akin to that of the pioneers, the sheer number of users in recent decades demands a greater responsibility by all in order to maintain a semblance of that spirit.

## Appendix I Explanation of Visual Impacts Rating System

Note: a.) Although individual rating explanations do provide a structured guideline, every feature within the explanation need not be present on the actual site to achieve that particular rating.

b.) If a site is determined to be between two ratings, than 0.5 should be added to the lesser rating. For example, if it is between 3 and 4, a score of 3.5 should be recorded.

Soil = any exposure of the O, A, B, or C horizons. In other words, the duff, top soil, bare soil or erosion pavement, and bare rock.

0 - no visible impact, soil appears the same as surrounding area.

1 - trampling is evident, but little or no soil exposed; possibly some small patches around fire or tent sites; duff maintained.

2 - a well defined central soil ring; trampling path(s) evident to tent site(s); may be some loss of duff or heavy compaction; soil exposed on less than 1/4 of site.

3 - central site and tent site(s) well defined with soil exposed along pathway(s); bare soil widespread, but less than 1/2 of site.

4 - bare soil on more than 1/2 of site; soil exposed in wide strips between central camp area and tent site(s); some erosion or rilling may be visible.

5 - bare soil covers more than 3/4 of site; visible erosion channels likely; soil movement obvious except in most protected sites; little distinction between central camp and tent sites, pathways assimilated.

cont ...

Vegetation - in general, the understory consists of plants below breast height and the overstory consists of plants greater than breast height.

Understory

0 - no trampling evident.

1 - vegetation compacted around fire ring and possibly at tent site; very little or no plant loss.

2 - distinct vegetation loss on central and tent site(s); pathway(s) to tent site beginning to lose vegetation.

3 - vegetation loss widespread, but some vegetation on at least 1/2 of site; pathway(s) to tent site(s) devegetated.

4 - vegetation loss on more than 1/2 of site; wide corridor devegetated between central site and tent site(s).

5 - vegetation stripped away on more than 3/4 of site; heavily compacted in all but the most protected sites.

Overstory

0 - no scarring, root exposure, or felling of trees or shrubs.

1 - may be some scarring of trees, most likely from hand carvings; little or no sign of wood gathering.

2 - scarring on up to 1/4 of trees, mostly minor cuts; possibly some limb breakage; small amounts of wood accumulation possible.

3 - scarring on nearly 1/2 of trees; 1 or 2 trees may be felled; some limb breakage evident; small amounts of root exposure; some surplus wood may be stockpiled.

4 - scarring on more than 1/2 of trees; root exposure evident, possible root damage; many lower branches stripped from trees; shrub damage; wood stockpiled.

5 - more than 3/4 of trees scarred; widespread root exposure and damage; almost complete stripping of lower branches; some mutilated shrubs; large amounts of wood stockpiled.

cont ...

Other = degree of rock displacement; presence of waste materials (manufactured and organic); construction of benches, seats, tables, special alterations or constructions for tents or shelters.

0 - no signs of human habitation.

1 - minimum signs evident; may be fire ring with small rocks or no rocks at all.

2 - distinct fire ring, larger rocks (depressions from rock displacement may be visible); possibly minimal seat construction.

3 - some permanent construction in addition to fire ring; presence of any metals, containers, wrappers, or feces (human or stock animal).

4 - permanent structures present; fire ring well developed with several large rocks or logs; some additional structures present; waste materials present.

5 - multiple seating structures; large fire pit; presence of additional structures more elaborate; possible stock retaining devices; waste materials may be abundant.

Appendix II. COMMON VEGETATION SPECIES OF SOUTH SLOPE CAMPSITES

| Scientific name | Common name | Location* |
|---|---|---|
| **Trees** | | |
| *Abies lasiocarpa* | subalpine fir | SA |
| *Picea englemannii* | Englemann sprue | SA,LM |
| *Pinus contorta* | lodgepole pine | LM,SA |
| *Populus tremuloides* | quaking aspen | LM |
| *Pseudotsuga menziesii* | Douglas-fir | LM |
| **Shrubs and Subshrubs** | | |
| *Berberis repens* | Oregongrape | LM |
| *Juniperus communis* | common juniper | LM |
| *Penstemon rydbergii* | Rydberg penstemon | SA |
| *Ribes monteginum* | mountain gooseberry | SA |
| *Vaccinium occidentale* | (no common name given) | LM |
| *Vaccinium scoparium* | broom huckleberry | SA |
| **Graminoids** | | |
| *Poa nervosa* | Wheeler bluegrass | SA |
| *Poa secunda* | Sandburg bluegrass | LM |
| **Forbs and Fern Allies** | | |
| *Achillea millefolium* | common yarrow | SA |
| *Antennaria alpina* | alpine pussytoes | SA |
| *Antennaria rosea* | rose pussytoes | LM |
| *Arnica cordifolia* | heartleaf arnica | LM,SA |
| *Castilleja applegatei* | sticky indian paintbrush | SA |
| *Fragaria vesca* | woodland strawberry | LM |
| *Geranium richardsonii* | Richardson geranium | LM |
| *Senecio integerrimus* | Columbia groundsel | SA |
| *Solidago multiradiata* | mountain goldenrod | LM,SA |

* SA = subalpine, LM = lower montane
In cases where both elevational zones are listed species are more commonly found in the zone listed first.

Appendix III. INDICATOR VALUES FOR ALL CAMPSITES BY USE AND ELEVATION

| | Lower Montane/ High Use (sites 1-6) | Lower Montane/ Low Use (sites 7-12) | Subalpine/ High Use (sites 13-19) | Subalpine/ Low Use (sites 20-25) |
|---|---|---|---|---|
| VIRS | 14 | 10 | 16 | 8.5 |
| | 10 | 4.5 | 14.5 | 11.5 |
| | 10 | 10 | 15 | 6.5 |
| | 9 | 11.5 | 13 | 12.5 |
| | 7 | 7.5 | 9 | 7.5 |
| | 17.5 | 7 | 10.5 | 12.5 |
| | | | 11.5 | |
| Total Camp Area ($ft.^2$) | 1544.96 | 334.9 | 2069.7 | 77.88 |
| | 1625.84 | 25.23 | 523.46 | 1116.41 |
| | 2137.92 | 2661.54 | 744.02 | 82.48 |
| | 450 | 2663.53 | 1029.02 | 278.46 |
| | 1503.43 | 3167.86 | 664.85 | 141.48 |
| | 713.21 | 1076.89 | 856.4 | 1615.25 |
| | | | 1734.94 | |
| Percent Bare Area | 45.65 | 41.33 | 76.14 | 95.92 |
| | 24.86 | 56.78 | 45.07 | 15.72 |
| | 24.76 | 20.46 | 65.36 | 71.62 |
| | 67.84 | 11.42 | 22.56 | 88.52 |
| | 8.7 | 10.81 | 53.76 | 59.55 |
| | 47.44 | 18.46 | 18.4 | 73.54 |
| | | | 44.51 | |
| Absolute Vegeta- tion Loss (%) | 22.16 | 10.89 | 38.42 | 16.5 |
| | 3.5 | 7 | 57.94 | 24.67 |
| | 8.42 | 2.96 | 23.79 | 18.25 |
| | 3 | -.06 | 23.17 | 42.25 |
| | 4.83 | 11.62 | 38.61 | 27.63 |
| | 26.75 | 5.75 | 26 | 49.59 |
| | | | 16.11 | |
| Relative Vageta- tion Loss (%) | 85.23 | 69.14 | 90.4 | 76.74 |
| | 82.35 | 40 | 95.25 | 88.9 |
| | 78.33 | 53.82 | 84.45 | 77.66 |
| | 41.38 | -3.28 | 94.88 | 94.41 |
| | 86.56 | 86.59 | 92.48 | 91.70 |
| | 93.04 | 74.19 | 90.43 | 92.83 |
| | | | 83.69 | |

cont ...

| | Lower Montane/ High Use (sites 1-6) | Lower Montane/ Low Use (sites 7-12) | Subalpine/ High Use (sites 13-19) | Subalpine/ Low Use (sites 20-25) |
|---|---|---|---|---|
| Absolute | 33.17 | 28.71 | 29.58 | 40.45 |
| Change/ | .83 | 25 | 32.97 | 10.5 |
| Mineral | 10 | 20.96 | 43.88 | 12 |
| Soil | -3.38 | 7.16 | 1 | 24.92 |
| Exposure | 9.8 | -2.22 | 23.76 | -1.5 |
| (%) | 39.63 | 6.9 | 9.92 | 41.92 |
| | | | 8.87 | |
| Relative | 97.07 | 93.49 | 65.73 | 55.86 |
| Change/ | 3.61 | 96.15 | 79.98 | 66.33 |
| Mineral | 46.51 | 64.41 | 76.14 | 22.33 |
| Soil | -12.29 | 32.06 | 4.88 | 42.84 |
| Exposure | 31.99 | -35.81 | 69.6 | -12 |
| (%) | 97.54 | 36.51 | 44.09 | 87.02 |
| | | | 31.35 | |
| Absolute | 11 | 15 | 14 | 5 |
| Damaged | 24 | 2 | 22 | 28 |
| Trees | 16 | 16 | 10 | 12 |
| | 21 | 59 | 27 | 49 |
| | 7 | 4 | 30 | 5 |
| | 68 | 9 | 19 | 22 |
| | | | 16 | |
| Percent | 12 | 19.73 | 21.88 | 20 |
| Damaged | 19.5 | 3.33 | 37.29 | 22.95 |
| Trees | 21.62 | 13 | 22.73 | 11.32 |
| | 16.94 | 49.58 | 28.13 | 45.79 |
| | 9.46 | 3.17 | 41.67 | 7.35 |
| | 38.86 | 5.52 | 19.39 | 40 |
| | | | 25.4 | |

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